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RECOVERY FROM NUCLEAR ATTACK And Research and Action Programs To Enhance Recovery Prospects

FINAL REPORT

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WORK UNIT 3539B

International Center for
Emergency Preparedness

Washington, D.C.

December 1979

ERRATA SHEET

Page 5, item (7), line 5: reads "expsoure", should read "exposure".

Page 27, Economic Viability, bullet 7: reads "technuiques", should read "techniques".

Page 34, para 4, line 4: reads "fo,uses up to", should read "faces up to".

Page 51, para 4, line 8: reads "health service", should read "Health Service".

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Page 68, para 6, line 3: reads "the first following an attack", should read "the first year following an attack".

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International Center for
Emergency Preparedness
2025 Eye Street, N.W.
Washington, D.C. 20006

by

Jack C. Greene
Robert W. Stokley
John K. Christian

for

Federal Emergency Management Agency
Washington, D.C. 20472

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SUMMARY

If the United States were to be subjected to nuclear attack, could it survive and recover? What research and action programs would improve prospects for recovery?

This study was undertaken to summarize the state of knowledge about these questions. Following an extensive review of the literature, conferences were held with more than forty scientists, as well as officials who have been involved in nuclear defense planning.

PART I of the report, entitled RECOVERY FROM NUCLEAR ATTACK, presents a nontechnical summary of research findings. It is written as an independent unit which can be separated from the rest of the report. It is organized to address the following "obstacles-to-recovery:"

Life Support Inadequacies
Epidemics and Diseases
Economic Breakdown
Late Radiation Effects
Ecological Effects
Genetic Damage

PART II entitled RESEARCH AND ACTION PROGRAMS TO EHANCE RECOVERY PROSPECTS presents a number of low-cost proposals primarily directed at developing practical but comprehensive management plans.

PART III is entitled PERSPECTIVES. It presents in Question-and-Answer form a number of reflections, derived mostly from the conferences, on such topics as economic modeling, functioning in a radioactive environment, and the Soviet civil defense.

Major conclusions of the study:

(1) Years of research have failed to reveal any single factor that would preclude recovery from nuclear attack. On the other hand, there is no way to prove that the nation could survive and recover. The major unanswered questions deal with human behavior, social and political disorganization, and the restoration of a functioning economy — all questions not of physical resources, but of "management." One of the most difficult problems would be learning to cope with ambient radiation. Relatively little attention has been given to these critical problems.

(2) The lack of realistic plans to reorganize and manage surviving resources could be an "Achilles heel." It is a critical deficiency that could be corrected at relatively low cost, but first the requirement must be acknowledged. A first step would be withdrawal of the out-of-date National Plan for Emergency Preparedness issued in 1964.

(3) It is concluded from current level[illegible] effort, in the face of a problem which would undoubtedly dwarf all [illegible]s disasters, that the United States simply rejects the possibility of [illegible]r war. Not so the Soviet Union, which is making extensive preparations to survive, win, and recover if a nuclear war should occur.

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FOREWORD

Why is it that after a lapse of several years there should be renewed interest in recovery from nuclear attack from four official sources, acting independently? Two studies on this subject originated with the legislative branch — the Office of Technology Assessment's The Effects of Nuclear War, and the Joint Committee on Defense Production's report on Economic and Social Consequences of Nuclear Attacks on the United States. From the executive branch have come Howard M. Berger's A Critical Review of Studies of Survival and Recovery After a Large-Scale Nuclear Attack commissioned by the Defense Nuclear Agency, and this report sponsored by the Defense Civil Preparedness Agency (which has now become part of the new Federal Emergency Management Agency). At the very least, this coincidence of concern is noteworthy, but whether it indicates uneasiness with the changing world power balance, or merely dissatisfaction with the very tentative and disparate conclusions of past studies, is uncertain.

It is also significant that there should be such close agreement between four independent studies as to the essential facts; what is known, what is unknown, and what is probably unknowable. (See Appendix III for abstracts of the other three reports.)

The viewpoint from which this report was prepared was that of the research and planning requirements of the government agency charged with civil emergency preparedness. For this reason, a large part of the effort was devoted to talking with recognized authorities. We are especially grateful to the many persons listed in the Appendix who generously contributed their time and knowledge to help us. We are also grateful to the Contracting Office's Technical Representative, Dr. David W. Bensen, for helping us formulate questions, locate experts, and arrange meetings. We also wish to acknowledge the editorial assistance of Mr. Donald E. Thomas in drafting an early version of this report published as DCPA Information Bulletin No. 307 and to Ms. Margaret Garner for professional assistance in the DCPA Library. Dr. James O. Buchanan, DCPA Director of Research, not only saw the need for this study, but contributed many valuable ideas.

Any errors of fact or judgment remain those of the authors.

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SUMMARY

If the United States were to be subjected to nuclear attack, could it survive and recover? What research and action programs would improve prospects for recovery?

This study was undertaken to summarize the state of knowledge about these questions. Following an extensive review of the literature, conferences were held with more than forty scientists, as well as officials who have been involved in nuclear defense planning.

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Major conclusions of the study:

(1) Years of research have failed to reveal any single factor that would preclude recovery from nuclear attack. On the other hand, there is no way to prove that the nation could survive and recover. The major unanswered questions deal with human behavior, social and political disorganization, and the restoration of a functioning economy — all questions not of physical resources, but of "management." One of the most difficult problems would be learning to cope with ambient radiation. Relatively little attention has been given to these critical problems.

(2) The lack of realistic plans to reorganize and manage surviving resources could be an "Achilles heel." It is a critical deficiency that could be corrected at relatively low cost, but first the requirement must be acknowledged. A first step would be withdrawal of the out-of-date National Plan for Emergency Preparedness issued in 1964.

(3) It is concluded from current levels of effort, in the face of a problem which would undoubtedly dwarf all previous disasters, that the United States simply rejects the possibility of nuclear war. Not so the Soviet Union, which is making extensive preparations to survive, win, and recover if a nuclear war should occur.

INTRODUCTION AND BACKGROUND

During the 1963-1973 decade, the Defense Civil Preparedness Agency (and its predecessor) spent more than $17 million for contract research on recovery from nuclear attack. The Federal Preparedness Agency (and its predecessor agencies) participated, as did other Federal agencies, in the fields of their designated responsibilities. The U.S. Public Health Service, for example, conducted studies of postattack health and medical problems.

Beginning in 1973, however, almost no new postattack research was undertaken for several years. There were a number of reasons for this: the overall curtailment of research funds; the priority given by DCPA to research on crisis-relocation-planning, fragmentation of responsibility among the Federal agencies, and other less tangible factors.

There are now signs of renewed interest in research on recovery from nuclear war. Several small contracts (including this one) were let in 1978. A major government reorganization has focused responsibility for this subject in the new Federal Emergency Management Agency. Finally, the national debate over the SALT II Treaty has led to intensified Congressional interest in all aspects of national sec· · ·.

In reviewing this subject, the -year hiatus in research activity may actually have been of some advantage. It was possible to obtain a perspective that only time affords.

Research Methodology: The Literature Survey

A complete listing of reports on postattack research was obtained from the Legislative Reference Service of the Library of Congress and from the Defense Documentation Center. Most of these reports were found to be readily accessible in the DCPA research library.

During the period when funding was available for postattack recovery studies an impressive amount of work was accomplished. A total of 369 reports based on this effort are available in the research library (as of July, 1979). Taken by subject area the breakdown of reports is as follows:

Radiological phenomena and effects	101 reports
Radiological countermeasures, procedures and processes	83 reports

Repair and reclamation of damaged facilities	62 reports
Postattack medical, health and welfare studies	36 reports
Postattack systems studies	87 reports

Other categories of DCPA research, although not directly aimed at postattack problems, nevertheless contain relevant material. The more important of these categories are:

Emergency Medical Studies
Civil Defense Systems Analyses
Vulnerability Studies
Social and Psychological Studies

Several DCPA (FEMA) research projects now underway are more or less related to the postattack recovery problems. We have talked to the contract monitors and to several of the principal investigators about this work, but have not attempted to summarize it in this report. Much of it is in an early stage, and up-to-date information can best be obtained directly from the contract monitors (principally George Divine and David Bensen).

We note that some of the research effort that we identify as being needed is, in fact, already underway. The total level of effort is very low, however, compared to the level of effort needed.

Abstracts of research findings contained in all of the DCPA research reports (as a uniform requirement) greatly facilitated our review. Also helpful was a 1969 seven-volume report of the MITRE Corporation prepared for DCPA which abstracted reports relating to postattack health and medical reearch, demographic effects of nuclear war, economic recovery management, economic production problems, critical postattack resources and industries, and socio-psychological problems.

We found the most useful single document available to be the Proceedings of the Symposium on Post-attack Recovery from Nuclear War sponsored by DCPA, OEP, and the National Academy of Sciences in November, 1967, published in April, 1968.

Also valuable was a critical review and synopsis of 94 research reports on survival and recovery from nuclear attack prepared by Howard W. Berger, issued by the Defense Nuclear Agency in December, 1978. During the

past year two new reports on the effects of nuclear war have been issued by the legislative branch. One is the Effects of Nuclear War prepared by the Office of Technology Assessment. The other, entitled Economic and Social Consequences of Nuclear Attack upon the United States was issued by the Joint Committee on Defense Production. (Abstracts of the three reports are contained in Appendix III.)

Methodology: Framework for the Report

In consultation with the DCPA contract monitor, Dr. David Bensen, it was decided to summarize the state of knowledge about recovery prospects by broad subject areas, rather than summarizing the findings of separate research reports, which, as indicated above, has largely been done. This places the focus of the report on the state of knowledge rather than on the effectiveness of past research work. It also facilitates a broader usage of the report.

In keeping with this decision to make the report meaningful to a wider audience than is customary with research reports of a technical nature, it was decided to follow a format which would (1) identify the major obstacles to recovery and (2) summarize the current state of knowledge regarding each obstacle. The basic framework was the list of obstacles to recovery used in the 1967 Symposium cited above, expanded along the lines used in OCD Research Report No. 16, The Case for Civil Defense, by Jack C. Greene, revised in 1972.

The obstacles to recovery thus chosen are:

Life Support Inadequacies
Epidemics and Diseases
Economic Breakdown
Late Radiation Effects
Ecological Effects
Genetic Damage

A first version of the summary report was completed in February, 1979. After formal review by DCPA, it was issued in May of 1979 as DCPA Information Bulletin No. 307. Six thousand copies of the bulletin have been printed and distributed. Another report, entitled Studies of the Post-Attack Environment: Overview and Assessment of Research Requirements, has been prepared by the Analytical Assessments Corporation under contract to the Defense

Nuclear Agency. As of September, 1979, the report was in the process of final review by DNA, with the expectation that it will be available before the end of the year. Authors are Jeffrey T. Richelson, Howard M. Berger, William T. Lee, and Abraham R. Wagner.

Metnodology: The Interviews

As noted, little postattack research has been conducted during the last 5 years. To bring the subject up-to-date, it was necessary to consult with as many of the principal authorities as we could locate. A list of prospective people to be consulted was developed with the help of Dr. David Bensen. In a number of cases, Dr. Bensen participated in the discussions.

More than 40 conferences were conducted -- a major part of our research effort. No person contacted refused to meet with us, and all were very unselfish with respect to the time and thought they gave to the discussions. Invariably, their comments were constructive. The list of those who generously shared their time and talents is contained in Appendix I. We gratefully acknowledge their help.

As a general procedure we have not attributed suggestions or comments to particular individuals. This was a general understanding reached during each discussion. However, it was also agreed that where we did associate a particular individual with a comment or suggestion, we would seek his express approval. This understanding undoubtedly contributed something to the frankness of the discussions.

Procedurally, each of the persons interviewed was provided a copy of a preliminary summary of our findings on prospects for recovery from nuclear attack, as contained in DCPA Information Bulletin No. 307. In addition to asking him to review this document and note any points of difference, each person was asked to anticipate questions regarding actions and research needed to improve recovery prospects. In a few cases the interview was conducted prior to completion of the summary report, which had to be provided afterwards, but the procedure outlined above was followed in all other cases.

Following the interviews, we revised the summary of the state of knowledge regarding prospects for Recovery from Nuclear Attack and include it as the first section of this report. It has benefited greatly from review

and suggestions from many people. It is worth noting, however, that there was little disagreement with the major conclusions contained in the original summary.

In general, the conferences were successful for one overriding reason -- the general conviction that postattack planning and research (today sadly neglected) are critical elements of our national security.

Special Factors: Human Behavior and Political Disorganization

Breakdown of constructive behavioral norms among the survivors, and political disorganization, are factors which might have been identified as specific additional obstacles-to-recovery. There is a body of professional opinion that believes that there would be a breakdown of human behavior, resulting in rioting, looting, even anarchy. Survivors would be so resentful of the leaders who "got us into this mess" that they would thwart all efforts to get them out of it. Others, equally competent, argue that survivors would cooperate with any organized program which appeared to be in the general interest and which did not run directly counter to their perceived personal interests.

The psychiatrist, Robert J. Lifton of the Yale University Medical School, has studied the behavior of the survivors of the atomic bombing of Japan. His book, Death in Life: Survivors of Hiroshima, Random House, New York, 1968, as reflected by its title, takes a pessimistic view.

Two scientists who are inclined to be more optimistic are Charles Fritz, a staff member of the National Academy of Sciences, and Peter G. Nordlie, of Human Science Research, Inc. Both have spent many years studying how people behave during and after disasters of various types, in peace and in war. Both believe that behavioral patterns among survivors would be strongly adaptive. Both support the case for additional research, believing that with proper planning "human behavior" can be an advantage, not an obstacle, to recovery.

The argument that political collapse would pose a major obstacle to recovery is similarly debatable. There can be no question that political organization will be severely strained following a nuclear attack, but there is little agreement as to what aspects of our present governmental apparatus are truly essential to recovery.

Because the evidence is unconvincing, we have not chosen to identify either human behavior or political disorganization as obstacles to recovery. We do suggest that planning and research should specifically factor behavioral and political aspects into all preparedness planning. It is obvious that individual and political behavior affect the entire listing of "obstacles." They should therefore be considered within the context of each, rather than as separate and independent subjects.

Special Factors: The Radiological Dimension

To the untrained observer, a city destroyed by a nuclear bomb and one destroyed by a major earthquake might appear much the same -- buildings leveled, fires burning out of control, chaos and desolation beyond immediate comprehension. The critical difference, of course, would be radiological contamination.

Over the centuries, man has often coped with the kind of damage caused by earthquakes, or massive destruction by fire, flooding, or bombing. Many cities have been rebuilt repeatedly. But we have no experience in dealing with physical destruction and the deadly killer, radioactive fallout, at the same time. As the recent experience at Three Mile Island demonstrates, many people are fearful, even unreasonably fearful, of radiation. (This is an example of the observation that each "obstacle" has a human behavioral aspect to consider.)

Much good work has been done on the postattack radiological problem. For example, much has been learned about the effectiveness of various methods of radiological decontamination. But the general question remains: How can society learn to function in an environment where radiation levels are higher than they have ever been in previous history, and many times higher than maximum exposure levels permitted workers in nuclear plants today?

There are many aspects to this general question. How could vast amounts of radioactivity be disposed of, with some degree of safety, at the lowest cost? How much exposure could be permitted under differing circumstances for various age and sex categories of the population? How much migration should be encouraged to minimize exposure, and how could it be managed? More simply, how could the average person know how much radiation

he was getting, and how could he control it? The list of questions could be extended, but the central point should be clear. The radiological dimension of postattack planning and research merits proportionately more attention than it has received in the past, both because of i's relative novelty, and because of its overriding importance.

No additional study, however, is needed to support these conclusions:

1. We are in need of more, and less expensive, dose and dose-rate meters. (Without instruments all efforts to control radiation exposure are doomed to failure.)

2. We must get the professionals involved in planning and development of doctrine and training programs and organized so as to be available to help out if the need should arise.

   (The National Council on Radiation Protection and Measurements is organizing a special scientific committee to study how NCRP could provide support in the event of a major radiological emergency — an action which is a direct by-product of this study.)

   (Other organizations, particularly the Health Physics Society, need to become involved.)

The Definition of Recovery

This report focuses more on the conditions requisite for recovery than on the components of the accomplished state.

There is no official definition of "recovery" from nuclear attack, nor is there likely to be. The organic law, the Federal Civil Defense Act, Public Law 920, 81st Congress, states that the mission of civil defense is to study and develop measures "to afford adequate protection of life and property." The Act was passed in 1951 before the time that an enemy attack could appear to threaten the very survival of society.

Executive Order 11490 on October 30, 1969, addresses the subject indirectly in setting forth responsibilities of the various Federal agencies for civil emergency preparedness. It requires that each department and agency make plans and take actions as necessary to assure that it would be able to perform its essential functions and continue as a viable part of the Federal Government during any emergency that might conceivably occur.

The National Plan for Emergency Preparedness issued in 1964 is also nonspecific. It calls for the preservation of the basic values of the nation, protection for the free exercise of constitutional and other basic rights and liberties, protection of representative constitutional government, maintenance of law enforcement and judicial processes, continuation of a basically free economy and provision for the continued operation of the government.

In performance of work under this contract, every effort has been made to determine a valid working definition of "recovery." Some of the possibilities considered:

— status quo ante - A definition of recovery that at first glance would seem acceptable is return to prewar status both internally and in relation to other nations. This would mean the same number of people, under the same political system, having comparable demographic characteristics, and with a similar economy. This would take several decades to achieve unless encouraged by massive immigration. It would also seem ridiculous if pushed to extremes, such as recreating slums, ghettoes, unemployment, and so on.

— Preattack standard of living - Return to preattack GNP per capita has been used in other studies as a reasonable recovery goal. But would we have achieved recovery if there were ten survivors living at this level?

— Preattack world position - Carthage did not recover from the Third Punic War, nor did Rome recover from invasions by the Visigoths and Huns. They were defeated and effectively destroyed. But neither does recovery depend upon winning the war. Germany and Japan were defeated in World War II, but both have achieved dramatic recoveries.

— Preattack values - Of great concern is a return to a system of political and economic liberties, but it is generally agreed that this probably depends upon achieving a strong and viable position among the nations of the world. It is not an independent variable.

— Preattack military position - To the military planner recovery means, at a minimum, return to relative preattack standing among the powers of the world. It is a goal, however, which cannot be pursued without regard to economic and political consequences.

— Environmental recovery - This would occur only when the effects of nuclear war on the plant and animal ecosystems would no longer be evident. Alternatively, recovery could be defined as return to a new state of ecological balance not unfavorable to mankind's basic needs.

— Demographic recovery - This might refer to a time when postattack society has returned to its preattack configuration in terms of various age and sex distributions, percentages of profession categories, re-creation of family units, and so on. There would be many and obvious distortions in early preattack society, such as increases in the number of orphans, relative decreases in the number of very young and very old, relative decreases in professional and managerial personnel, etc. It is not believed, however, that demographic reconstitution of society can be accepted as a valid working definition of recovery, nor can the makeup or a viable, as contrasted with a nonviable society be known in advance.

The foregoing discussion serves to reinforce the conclusion that it is not, in fact, practical to define "recovery from nuclear attack" in specific terms. The postattack society will define its own recovery goals, provided it has the opportunity to do so and the requisite conditions for recovery exist.

Opportunity to recover means simply that the United States must not lose the war. The requisite conditions for recovery, according to Bernard Sobin, exist when:

> "... (a) losses of population due to failure of the economy to support those surviving the shelter period have been negligible, and (b) future production of goods and services sufficient to meet consumption requirements of the government agencies and of the population indefinitely is assured ..."

Although Sobin's requisite conditions for recovery are phrased in economic terms, they adequately subsume other criteria such as a labor force well-nourished and adequately motivated, an environment not hostile to human life and recovery, etc.

As noted, the focus of this report has been on the conditions requisite for recovery. There is little practical value in attempting to define recovery itself.

Comments on Postattack Research

A principal purpose of postattack research is to generate information needed to establish national policies. Research produces input for the people who determine the country's policy regarding plans and preparations for recovery from nuclear attack.

PART 1

RECOVERY FROM NUCLEAR ATTACK

(This part of the report constitutes a nontechnical summary of the state of knowledge about the prospects for recovery from nuclear attack. It was written and printed so as to stand on its own when separated from the remainder of the report. [An earlier version of this was distributed by DCPA as Information Bulletin No. 307, dated May 10, 1979.])

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by

Jack C. Greene
Robert W. Stokley
John K. Christian

International Center for Emergency Preparedness
Washington, D.C. 20006

for

Federal Emergency Management Agency
Washington, D.C. 20472

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Dr. David W. Bensen (COTR)

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PART I: RECOVERY FROM NUCLEAR ATTACK

INTRODUCTION

On December 5, 1945, just 4 months after the news flash that an atomic bomb had been developed by the United States and had been dropped on Japan, Dr. Hans Bethe, Nobel prizewinner and one of the designers of the bomb, was called before the Special Committee on Atomic Energy of the U.S. Senate. The Committee was concerned that an atomic explosion might "ignite" the earth's atmosphere or start some sort of chain reaction in the air or in the ocean.

Dr. Bethe succeeded in reassuring the Committee that these and other "end-of-the-world" type effects are not to be expected. In general, such extreme fears no longer are taken seriously. However, other almost equally catastrophic visions have arisen to take their place. They include:

— the triggering of a new ice age, to be caused by the vast quantities of debris that would be thrown into the stratosphere and would serve to deflect the sun's rays away from earth. (Although we cannot rule out the possibility of some changes in climate if a very large scale nuclear exchange should occur, most of the particles would descend airly quickly and the changes in climate, even if noticeable, would be transitory.)

— upsetting the delicate balance of nature, leading to disastrous changes in the ecological systems. For example, it has been suggested that since birds are more sensitive than insects to gamma radiation, fallout could kill off the birds - the predators - leaving the insects - the prey - to multiply without control. (Study has shown that when other relevant factors are considered, this is not likely to occur. The insects would be subjected to much more beta radiation than the birds, and control mechanisms other than simple predator/prey relationships affect population control.)

— creation of vast radioactive wastelands that would be uninhabitable for generations. Some areas, especially near ground - zero of surface - burst weapons, would continue to be highly radioactive for many years. (Much of the country, however, would be scarcely affected at all and much of it initially interdicted because of fallout could be reclaimed by decontamination, or, within weeks or months, could be used after the natural radioactive decay had reduced the radiation levels to acceptable values.)

— great increases of leukemia and other malignancies among the survivors – due to exposures to fallout radiation. In the 50's and early 60's many people believed that survivors of a nuclear attack inevitably would die of bone cancer from Strontium-90, (Research has shown that Strontium-90 is not the hazard it was first thought to be. The basic reason is that most of the bomb-produced Strontium-90 is not "biologically available;" that is, it does not get into the food chain. Also, methods for decontaminating food have been developed if the need should ever arise. Some increase in the rate of malignancy among survivors of a nuclear attack would be expected, but in no sense would the increase threaten the survival of the society.)

— vast increases in congenital defects due to gene mutations caused by radiation, lasting for many generations. (Some radiation-induced genetic mutations would occur among the survivors of a nuclear war, but, as in the case of the malignancies, their impact would not be important in terms of the survival of the society.)

— depletion of the ozone layer in the stratosphere. This could decrease protection from ultraviolet radiation and cause proliferation of skin cancers, kill wild and domestic animals, and make it difficult, if not impossible, to grow many of the crops that provide our food and fiber. (This hypothesis is the latest and its validity is yet to be established one way or the other. If research confirms that ozone depletion resulting from the detonation of nuclear bombs is a serious potential hazard, research would be needed to evaluate the degree of the hazard and what could be done to reduce its effects.)

— breakdown of our highly sophisticated and complex social and economic systems due not only to loss of key facilities and personnel, but also because of functional disruption and behavioral breakdowns. (This hypothesis is less specific than those relating to the physical effects of nuclear weapons, and is much more difficult to formulate or investigate. It remains at this time one of the major "unknowns.")

An underlying basis for these negative hypotheses may be psychological. If everyone "knew" that nuclear war would mean the end of the human species, somehow the world would appear more secure since no sane person would initiate a series of events that would lead to everyone's death, including his own. In such a way does the idea of "assured destruction" contain elements of reassurance to some people.

There may also be an extreme extension of this psychological factor. Some people may feel it is dysfunctional or even immoral to study the problems of recovery from nuclear attack. Reinforcement of the pessimistic point of view is unnecessary while any optimistic findings could appear very threatening by somehow increasing the chance that nuclear war might actually occur.

The potential threats to recovery from nuclear war have received a significant amount of study. The Defense Civil Preparedness Agency (and its predecessors) in the decade from 1963 to 1973 allocated some $17 million to research in the general area of postattack recovery. The Federal Preparedness Agency (and its predecessors) have conducted both contract and in-house research at a cost of another several million dollars, with much of this FPA work focused almost exclusively on the problem of economic recovery.

Other agencies have also been involved. From the early days following World War II the former Atomic Energy Commission and its successors, now the Department of Energy, have sponsored elaborate research programs aimed at investigating the various possible deleterious consequences of exposure to ionizing radiation and developing means of protecting against them. This radiological research program has included a cooperative effort with the Japanese to study the longer-term effects of radiation exposure on the survivors of Hiroshima and Nagasaki and their offspring. This program continues today, and will for many years to come.

To date, approximately $1.5 billion has been allocated by the AEC and its successors for research associated with ionizing radiation and its effects. From these 30 years of scientific studies, much is known about the hazards of radiation — more than is known about many of the other hazards that man faces, probably including the common cold.

THE EFFECTS OF A NUCLEAR ATTACK

A nuclear attack on the United States would be enormously destructive. It is not possible to predict the delivered weight of weapons or their exact destination. However, many studies of hypothetical attacks have been made and it is now possible in unclassified documents such as this to indicate the general magnitude of destruction and the likelihood of survival.

In short, the prospects are:

— 1 in 3 of being killed outright by blast or thermal effects;

— 1 in 6 of being killed by fallout radiation;

— 1 in 6 of being injured, but nonfatally, by blast, thermal or fallout radiation;

— 1 in 3 of being uninjured.

These are gross estimates, of course. They vary considerably, depending upon such factors as type of attack, (a counterforce attack as contrasted to an industry attack, for example), and on the weight of the attack. The amount of warning and the status of civil defense preparedness also would have an important influence. The estimates above are based on the assumption that civil defense at the time of attack is essentially the same as it is at the present time (1979) and that the attack is a major strike against a mixture of counterforce and industrial targets.

The estimates would also vary depending on how the casualty calculations are made. The "damage functions" used in the computer programs for the calculations represent a less-than-perfect understanding of how the bomb-produced blast, thermal and ionizing radiation phenomena interact with structures and with people. However, damage functions which are reflected in the numbers given above represent many years of research and major improvements or changes are unlikely.

Even if a nuclear attack on this country should occur, resulting in the death of half the population, there would still be over 100 million survivors - approximately the population of the United States in 1921. In many ways, however, this society would differ from the preattack version.

The general nature of these differences can be assumed from analysis of hypothetical attacks, studies of human behavior in past disasters, and other studies of demographic and societal vulnerabilities. The more important differences include:

(1) Many of the fatally injured would not die during the attack itself or immediately following it. For example, radiation casualties might not die for weeks or months later. Thus, care of the injured would place a heavy burden on the uninjured survivors.

(2) The population would no longer be predominantly urban, since the urban areas contain many of the preferred targets. Therefore, a considerably higher percentage of the rural population would survive.

(3) The male-female ratio would remain about the same, but the age distribution would be different. On a percentage basis, there would be considerably fewer of the very old or very young since these age groups are more vulnerable to stress, including the effects of nuclear weapons.

(4) The life expectancy of the average individual would be shortened, perhaps by as much as 4 to 5 years.

(5) Proportionally there would be fewer doctors and hospitals, corporate headquarters and executives, petroleum refining and pharmaceutical production plants, and public administrators, since all tend to be concentrated in the larger cities.

(6) Many of the male members of the surviving population would become sterile because of radiation exposures, but this condition would only be temporary.

(7) There would be genetic injury, but the extent could be reduced by keeping controllable radiation exposures as small as possible for all who are likely to produce children at a later time and by avoidance of conception during the first few months after expsoure.

(8) There would be an increase in the percentage of orphans and other dependents in the population as well as an increase in broken families. Even if an entire family were together at the time of the attack, some family members might survive while others would not.

(9) There would be changes in the composition of the labor force, both in terms of geographic availability and distribution of skills.

(10) About 50 percent of the manufacturing capacity of the nation would be destroyed and an additional 20 percent damaged -- some of it irreparably. Of the remaining 30 percent, not damaged, some would not be accessible for weeks to months until radiation levels decayed or until decontamination operations were performed.

(11) Many domestic and wild animals and crops would be killed or severely damaged primarily by the fallout radiation; however, compared to people, a proportionally higher percentage of animals and crops would survive.

(12) This postattack society would have to learn to function in environments where the ionizing radiation backgrounds are many times higher than experienced by any previous society in history. People would learn how to avoid or minimize the consumption of contaminated food and water, and how to ration their exposure to external sources of radiation, even though there is an insufficient number of radiation measuring instruments -- especially dosimeters.

(13) Widespread panic probably would not occur. The general behavior pattern among the survivors, following a major disaster, would be adaptive rather than maladaptive. By and large, people could be counted on to participate constructively if there is a recovery plan that seems to make sense. (This behavior pattern assumes that individuals could obtain the basic requisites for existence -- food, water, shelter, etc. -- for themselves and their families.)

OBSTACLES TO RECOVERY

Survivors of the direct blast and early fallout effects would still face an uncertain future. Serious additional hazards and obstacles would have to be overcome. Some of the hazards would have to be faced immediately; others would not become important for months or even years. In this respect the recovery process can thus be thought of as an "obstacle course" with the hurdles arranged in order.

Before recovery can start, individuals would have to survive the blast and thermal effects, the high intensity fallout radiation levels, and the prospect of being trapped without rescue or medical help. Once through the immediate postattack period (roughly the first week), there would still be many other obstacles to overcome.

The major elements in this "obstacle course to recovery" and the times during which they could be most important are outlined below. (The times associated with each are not intended to be precise, but are given to provide a rough idea of when this influence is likely to be of greatest importance.)

Time After Attack	Attack Effect
1 – 2 days	Blast and thermal
2 – 20 days	Lethal fallout
2 – 7 days	Trapped; no medical treatment
5 – 50 days	Life support inadequacies (food, water, shelter)
2 weeks – 1 year	Epidemics and diseases
1 – 2 years	Economic breakdown
5 – 20 years	Late radiation effects
10 – 50 years	Ecological effects
2 – several generations	Genetic effects

These obstacles are not necessarily independent of each other. As examples, people might expose themselves to fallout radiation in search of food or water, which would contribute to late radiation effects and genetic damage; or malnutrition could lower resistance to diseases. For purposes of exposition, however, each of these obstacles will be discussed separately.

1. LIFE SUPPORT INADEQUACIES

People who have to remain in fallout shelters because of continuing high external radiation levels may run out of food and water. Unless adequate supplies of drinking water are maintained, severe consequences will be experienced within a very short time. People either will leave the shelter in search of water, thereby exposing themselves to excessive radiation doses or they will become ill from dehydration. If water is completely denied, deaths will begin to occur in a few days.

Food supplies are less critical. Most people could survive a period of several weeks on a severely limited amount of nourishment. The most serious consequence could be hunger-motivated pressure to emerge prematurely from shelter in search of additional food supplies.

As is the case with almost any kind of severe stress, the early victims would be those who are least resilient -- the very young, the very old, and the infirm.

Research has revealed that the food and water problem would be one of distribution, not one of insufficient resources. Although water distribution systems could be damaged and water service interrupted, analysis has shown that in most cases enough water for drinking would be available -- trapped in the plumbing -- in hot water heaters -- in the flush tanks of toilets, and the like. Proportionally, far more food would survive than would people to consume it. The problem would be getting the food from the places where it exists to the people who would need it.

It is obvious that the more food and water stored so as to be directly accessible to survivors the better. It was for this reason that the national food and water stockpiling program for fallout shelters was carried out in the 1960's. With such a program, the need for rapid reestablishment of food, water and power distribution systems is less critical.

Radiological contamination of food and water should not be a seriously complicating factor. With simple precautions people could avoid use of food and water with excessive contamination levels. Most people should not be affected to any significant extent.

In summary: There is no intrinsic reason why life support requirements for the survivors of a nuclear attack should not be met. The basic problem would be to get the more-than-adequate surviving supplies of food and water to the people who need them. Prototype studies have been made and sample plans developed for selected localities. What is needed is the development of individual plans tailored to meet the needs of individual localities and situations throughout the country. A modest investment in planning and perhaps some stockpiling should assure that this obstacle to recovery could be overcome by most of the survivors.

2. EPIDEMICS AND DISEASES

There are a number of factors which are potential contributors to an increased per capita incidence of epidemics and diseases in a post-nuclear war society. They include:

(a) Destruction, damage or disruption of many sanitation facilities and waterworks.

(b) General disruption of public health organizations and loss of personnel that could result in the lowering of public health practices and disease surveillance systems.

(c) Inadequate supplies of preventive, prophylactic and therapeutic chemicals (vaccines, anti-toxins, antibiotics, and other necessities for disease control) due to a heavy demand in the face of production losses and distribution problems.

(d) The higher-than-normal radiation exposures to which the survivors of nuclear war will have been subjected might enhance susceptibility to infection and disease.

Counterbalancing factors could serve to prevent or limit the development and spread of epidemics or debilitating diseases:

(a) Most of the great epidemic diseases of mankind -- cholera, smallpox, typhus and yellow fever -- do not exist in the United States nor in most other societies today. Smallpox is believed to have been nearly eradicated from the face of the earth. Therefore, there are few reservoirs from which these epidemics could arise and spread. If we maintain an adequate immunization program, the danger is even smaller.

(b) Sources of broad-spectrum antibiotics which would have been severely depleted by the attack could be quickly created or augmented. Veterinary-grade antibiotics, which today are produced in copious quantities, could be used for humans in an emergency. With advance planning, the fermentation vats used to produce enzyme additives for detergents could be readily converted to produce penicillin. Expanded production also could result from concentrating on a few generic broad-spectrum antibiotics rather than making the numerous specialized varieties that are produced today.

(c) Surviving stocks of household bleaches could be used to augment the reduced supplies of water treatment chemicals. High priority to restoration of normal souces of supply would be important.

Even under the worst circumstances imaginable, there is little danger of a repetition of the "Black Death" that devastated Europe in the mid-14th century, or of similar potentially catastrophic epidemics.

Modest expenditures, primarily for developing detailed plans to augment supplies of broad-spectrum antibiotics and water treatment chemicals, and to carry out a comprehensive immunization program, could have a significant payoff in the event of a nuclear attack upon the United States.

In sum, the specter of pestilence and disease stalking the land in the aftermath of nuclear war is probably just that -- a specter, not a realistic probability. It need not, and probably would not, occur.

3. ECONOMIC BREAKDOWN

Before the potential for economic breakdown as a barrier to postattack recovery can be discussed realistically it is necessary to be specific about the meaning of the term "economic recovery." Development of a definition of recovery acceptable to everyone probably is impossible because inherently what constitutes recovery is subjective. Things very important to one individual may be unimportant to someone else. For this reason the focus here is on the prerequisites for recovery rather than recovery itself.

Dr. Bernard Sobin, a scientist at the Research Analysis Corporation, in a 1970 research report suggested that the conditions necessary for recovery from nuclear attack cannot be met unless:

> (a) "losses of population due to failure of the economy to support those surviving the shelter period have been negligible, and
>
> (b) future production of goods and services sufficient to meet consumption requirements of the government agencies and of the population indefinitely is assured ... recovery is not assured if meeting consumption requirements depends upon depletion of some inventory without provision for ultimate replacement."

In addition to the outright destruction of perhaps half or more of the United States industrial plant capacity and the similar reduction in the labor force, many other considerations contribute to the possibility of economic breakdown. They include:

> (1) The high degree of specialization of industry which makes for an equally high probability that some part of the production chain will be damaged. (But the existence of many similar competing plants increases the likelihood that broken production chains can be reconstituted.)
>
> (2) The flow of raw materials and parts could be seriously interrupted, and plant inventories of goods-in-process might or might not be of future value.
>
> (3) Transportation linkages could be disrupted. (But there is great redundancy in the transportation system, especially in trucking. Fuel might be the major limiting factor.)
>
> (4) Public utilities such as power, water, and communications could be out of operation in many areas for a long time, curtailing production.

(5) Much of the surviving population might be too preoccupied with personal considerations to reenter the labor force.

(6) There could be disproportionate losses of managers and highly skilled workers.

(7) Lines of authority in many industrial enterprises could be broken. The authority of surviving plant managers to make decisions could be unclear. (The role of government in setting production goals and supporting them with allocations of materials and credit, guaranteed purchases, or establishment of a "futures market" remains unclear.)

(8) The markets for which goods are produced may have disappeared with the attack. The "order book" could be worthless as a guide to future production.

(9) Money, both specie and commercial deposits. could quickly become worthless. A new money, based on the realities of postattack values, would be difficult to establish. Without a monetary system which represents a reliable "store of value," complex economic activity could virtually cease.

(10) Property rights could be in a state of chaos for some time. Many people could have lost everything - real property, securities, jobs. Insurance probably would be worthless in most cases. Other persons in possession of undamaged property, or inventories of food, medicine, fuel, and the like, could become rich overnight. Many of the dead would have died intestate; surviving heirs could not quickly establish their claims; courts would be overwhelmed. There would be cogent demands for war indemnification, with difficult problems of equity, social order, and economic efficiency involved.

These are some of the major components of the economic recovery problem. It is readily apparent that the economic factors interact at every point with political, social, behavioral, and institutional problems. The economic system cannot be restored unless certain preconditions are met: law and order, restoration of utilities, a set of future expectations which are based on a functioning national, social and political system, a reliable medium of exchange, and so on.

A useful way to look at the postattack economic problem is to divide it into two parts — the physical part and the management part. Would the physical constituents of the economy — land with acceptably low radiation levels, seeds, fertilizers and pesticides, industrial plants, energy, raw materials, transportation, a labor force with necessary skills — be

available so that, if used in an efficient way, the goods and services required by the survivors could be produced? If not, economic recovery could not occur and the question of management is academic.

Germany in the early period following World War II provides an example of a country which was limited initially by lack of the necessary physical resources for recovery. Her production capacity had been severely damaged by intensive Allied bombing raids and much of the industry that survived had been dismantled and carted off to the Soviet Union. There is little question that outside assistance from the United States under provisions of the Marshall Plan played a dominant role in the rapid and remarkable recovery of West Germany. When the physical resources became available, the Germans managed them very well.

The United States of the 1930's on the other hand is an example of a country with an abundance of physical resources, but with a temporary breakdown in its system for managing them. Recovery from the Great Depression of the 1930's did not occur because of outside help, but because of the adoption by the government of new techniques of fiscal and monetary stimulation – measures that were greatly augmented by the advent of World War II.

Achievement of conditions that will assure recovery requires not only the physical and manpower resources for production, but also that these resources be managed competently. Would the government provide effective leadership? Could it develop and promulgate regulations and policies and provide assistance conducive to recovery, and when mistakes were made would this fact be recognized so that correction could be made quickly and effectively? Could management obtain the necessary information on raw material supplies, current & future markets, transportation possibilities, and the like? Could this information be applied effectively to organize, plan, lead and control this damaged economy?

The Physical Problems

Do we have confidence in the ability to forecast the kinds and degrees of damage that could result to United States industry and its production capacity in the event of nuclear war?

The answer is yes, but it is a qualified yes.

Limitations in the ability to predict levels of damage to the various industrial sectors probably lie mostly in the uncertainties about the type of attack (targeting) an enemy would undertake and the number and explosive power of the weapons that would be used.

Given a particular pattern and weight of attack, prediction of damage to a major industrial sector — say oil refineries -- or a certain agricultural zone -- say the wheat and cornfields of the Midwest -- probably can be quite realistic. The prediction of physical damage to a particular industrial plant or the fallout level at a specific location, however, is much more uncertain.

A number of highly sophisticated damage assessment models and the requisite data bases (location of industrial plants, key bridges and other possible targets) have been programmed for high-speed computers. With these techniques, nuclear wars can be simulated and the results depicted quickly and in great detail. Variations in assumptions about the capacity and objectives of an enemy, and assumptions about differing United States defense capabilities are studied in this manner.

Such studies indicate that an attack intended to damage selected critical industries could succeed in reducing their capacity to small percentages of preattack levels. Petroleum refining, iron and steel plants, drugs, engines and turbines and the measuring devices for industrial processes are particularly vulnerable. However, such attacks do not destroy the final few percent of capacity of any industrial sector because of wide dispersal and because of the difficulty a foreign nation would have in learning the exact location of each and every United States facility.

It should be kept in mind that weapons aimed at specific industries because of their importance for recovery could also be aimed at missile sites or other military targets. Thus, the weapons that one side aimed at industry would detract from the effectiveness of its counterforce strike. A philosophy of targeting specific industries could mean the acceptance of greater damage to the homeland. With an unlimited supply of weapons, of course, this would not be the case.

Even without a deliberate attempt to create them, industrial imbalances inevitably would occur. Some economic sectors are more vulnerable than others because: (1) they are concentrated in different locations

(agriculture in rural areas and manufacturing in urban areas); and (2) because of differences in physical vulnerability (refineries are more easily damaged than are coal mines).

Also, there is a difference in response to the various nuclear weapon effects. It has been determined that people can withstand considerably higher direct blast pressures than buildings (although people in buildings destroyed by blast may die as a result of building collapse). Fallout radiation, on the other hand, may damage people, livestock and crops, but would produce no damage to inanimate objects such as buildings, farm equipment, and production machinery.

Numerous economic models have been developed that attempt to assess the production potential of a nuclear attack-damaged economy. One such model was designed by Dr. Bernard Sobin to evaluate the number of people that could be supported at various subsistence levels after a nuclear attack. In addition to the constraints relating to production capabilities, the model takes into account the available acreage suitable for growing particular food crops. It also takes into account the accessibility of this land - accessibility meaning human access is not denied by radioactive fallout.

Studies applying this model and others show that the degree of industrial damage to be expected even from a major attack does not produce bottlenecks which cannot be overcome by substitution, rescheduling, or other devices.

Common sense supports the idea that this country could continue to grow the food and fiber necessary to sustain its citizens after nuclear attack. The United States has a highly efficient agricultural industry. Only about 4 percent of the total population is required to meet the needs of the nation and provide huge surpluses for export. In a nuclear attack, farm machinery would be scarcely affected at all and the farm workers would not receive dangerous exposure provided they took simple precautions against fallout. Some agricultural land might have to lie fallow for a season because of fallout, but most of it would be useable within a relatively short time. Priority allocations of fuel for the farm machinery and of fertilizers and other farm inputs should make it possible to bring the agricultural industry back quickly to a highly productive level.

The studies referred to above deal only with the physical component of the economic recovery problem. Implicitly they assume effective management and that the human behavior factors, such as worker productivity and morale are as favorable as they are today. But perhaps the most difficult part of the problem is the expected performance of management.

Management Problems

Most of the central concepts for the management of the United States wartime economy evolved shortly following World War I, before development of the massive nuclear arsenals now possessed by the Soviet Union and the United States. The National Plan for Emergency Preparedness, (the official statement of government policy on the subject), is heavily oriented toward controlling the economy as was done during World War II and the Korean War. The principal goal then was mobilization of industry to produce war materiel, and the concomitant control of inflation.

In the event of a massive nuclear exchange between the United States and the Soviet Union, the question of continued production of war materiel may become largely academic. Nor would inflation be the primary concern. The stark question of how to meet basic subsistence needs of survivors so that recovery can begin must be answered before the society can afford the luxury of setting more ambitious recovery goals, such as return to the preattack standard of living.

Some obviously top-priority actions would be to:

- maintain communications;
- get essential transportation, petroleum refining, and utility systems functioning;
- keep the agricultural industry going;
- avoid further deterioration of damaged or idle production equipment or facilities;
- proscribe nonessential activities — at least those that would "waste" materials in short supply; and
- mobilize manpower — in particular, to assure that people with specialized skills needed in the recovery effort are used effectively.

There are also important questions about decentralization. The economist, Dr. Sidney Winter, while at the Rand Corporation, expressed his belief that more economic decisionmaking, both public and private, would need to be decentralized than is the practice in our present peacetime economy, simply because centralized control would be impossible.

Dr. Winter suggested that four of the major tasks for the federal government would be:

(1) Reestablishment of private property rights;

(2) Reestablishment of the use of money to prevent the inefficiency of a barter economy;

(3) Reestablishment of price expectations, possibly by operating a futures market and by a limited set of price guarantees; and

(4) Reestablishment of the traditional government operations in the provision of important public goods and services.

Dr. Sobin thinks that the nationalization of much of the surviving economy may be necessary. This would alleviate problems associated with reestablishing private property rights and would provide a mechanism for sharing the losses caused by the attack. Otherwise some businesses could be completely wiped out whereas others would be in a position to reap huge windfall profits. He does not support the idea of direct government operation of this economy as is the practice in the Soviet Union. Rather, private enterprise would continue through private operation of leased government-owned facilities.

Should the need arise, the plans and procedures for carrying out the above tasks would have to be developed on an ad hoc basis, for they do not exist today.

The dimensions of the postattack management problems are almost limitless. This is an extremely complex and important area that has received only meager attention. For this reason, it has been given somewhat greater prominence in this report than most of the other obstacles to recovery. Unless more creative and imaginative study is applied to develop better strategies for managing the postattack economy, this barrier to recovery could turn out to be the most difficult of all.

4. LATE RADIATION EFFECTS

Longer-term radiation effects would take their toll in the years following a nuclear war. They include thyroid damage, bone cancer, leukemia, and other forms of cancer of the types that occur today. Radiation does not induce new forms of cancer; it increases the frequency of occurrence of those which result from other causes. A physician examining cancer patients in the postwar world would not be able to discriminate between those caused by the fallout radiation and those which would have occurred anyway. The radiation exposures would increase the incidence of various types of cancer so that the net effect would be observable on a statistical basis. Years of research in this country and elsewhere demonstrate that there is no danger the increased incidence would be great enough to pose a threat to the survival of the society.

During a symposium held in 1967, the Chairman of the National Academy of Sciences Division of Medical Science, Dr. Charles Dunham, summarized such long-term biological effects of a nuclear attack by stating:

> "20,000 additional cases per year of leukemia during the first 15 to 20 years postattack followed by an equal number of miscellaneous cancers, added to the normal incidence in the population for the next 30 to 50 years, constitute the upper limiting case. They would be an unimportant social, economic and psychological burden on the surviving population." (Underlining added for emphasis)

This estimate was based on a surviving population of 100 million persons who had an average exposure of 100 roentgens — a realistic possibility. If (because of inefficient use of fallout shelters or careless exposure to fallout radiation afterward) the average exposure per survivor were higher than 100 roentgens, the expected consequences also would be correspondingly higher.

Perspective is provided by comparing the death expectancy among the survivors due to late radiation effects with the death expectancy from various causes in today's society. In the comparison, it is assumed that all the fallout radiation-induced leukemias and other cancers among the survivors result in death, which, of course, is extreme.

If 20,000 people in a society of 100 million survivors of a nuclear attack were to die each year from leukemia and other cancers caused by the attack, the average chance per individual of dying from this cause in a

single year would be 2 in 10,000. This 2 in 10,000 risk of death corresponds to the additional risk faced today by the average individual who:

Travels 80,000 miles by commercial air, or
Travels 12,000 miles by car, or
Spends 5 hours rock climbing, or
Lives about 3 days after his 60th birthday.

Perhaps it is more meaningful to compare with the dangers of cigarette smoking since in neither case is the consequence immediately evident. Both take their toll over a period of years. Statistics show that an individual whose smoking career lasts just a little over 2 years and who during this time averages a pack a day also faces an additional risk of death of about 2 in 10,000 over his remaining lifetime.

Another form of radiation — ultraviolet — might become a factor affecting the health of nuclear attack survivors. If the nuclear detonations should cause depletion of the ozone in the stratosphere, increased amounts of ultraviolet radiation would reach the earth, resulting in an increased incidence of skin cancers. The number would depend upon the intensity and duration of the ultraviolet irradiation and the extent to which the survivors protect themselves.

Whether or not there actually would be an ozone problem is uncertain. The evidence supporting the hypothesis that a nuclear war would result in a significant depletion of the ozone is highly theoretical and speculative. The limited observations following nuclear tests do not support this hypothesis.

In the 1961 - 1962 period both the United States and the Soviet Union tested atomic devices in the atmosphere. The yield was in excess of 300 megatons. A world-wide network of stations which, since 1960, has published daily ozone concentrations detected no evidence of an ozone decrease during the months following these test explosions, according to a paper by H. M. Foley and M. A. Ruderman for the Institute for Defense Analyses. Northern Hemisphere values seemed to show, if anything, a steady rise in ozone content.

In any case, further research and study is needed to evaluate more fully the extent of this potential hazard.

5. ECOLOGICAL EFFECTS

There is still uncertainty concerning the probable ecological consequences of nuclear war. Some fairly extensive study programs were undertaken during the 1960's but had to be abandoned because of lack of funds. Nevertheless, they produced some important results.

A 1963 report of a study by a committee of the National Academy of Sciences contains this statement: "Large-scale primary fires, totally destructive insect plagues, and ecological imbalances that would make normal life impossible are not to be expected."

A 1969 update, this time conducted under the auspices of the Oak Ridge National Laboratory, contained the following: "A reasonable conclusion, therefore, is that the long-term ecological effects would not be severe enough to prohibit or seriously delay recovery."

The various ecological catastrophes postulated to follow a nuclear war -- fire, erosion, flooding, pest outbreaks, epidemic diseases, and balance-of-nature disturbances -- have been individually examined in terms of their probable importance. The objective of the scientist who conducted this research, Dr. Robert Ayres, formerly of the Hudson Institute, was to:

> "... take seriously and examine in their own terms, all of the supposed mechanisms leading to catastrophe which have been subjects of speculation in recent years."

He summarized by saying,

> "We have not found any of these mechanisms to be plausible in terms of any reasonable definition of catastrophe."

It is noted that Dr. Ayres' study was conducted before the ozone depletion hypothesis became popular which, as mentioned earlier, should be subjected to careful analyses. In the future, other hypotheses for catastrophe undoubtedly will be developed. Those which seem to have any basis also should be taken seriously and subjected to scientific scrutiny.

To provide perspective on postattack ecology, it is useful to keep in mind that nature may not be so delicately balanced after all. No weight of nuclear attack which is at all probable could induce gross changes in the balance of nature that approach in type or degree the ones that human civilization has already inflicted on the environment. These include cutting

most of the original forests, tilling the prairies, irrigating the deserts, damming and polluting the streams, eliminating certain species and introducing others, overgrazing hillsides, flooding valleys, and even preventing forest fires.

6. GENETIC DAMAGE

In common with late-radiation and ecological effects of nuclear war, the genetic effects of radiation are widely misunderstood and consequently feared. The specter of a vast increase in congenital defects among our descendants is frightening. Perspective is hard to develop partly because any threat to our children is so laden with emotion.

But a great deal is now known about the genetic effects of radiation. Dr. H. J. Muller, an American geneticist, received a Nobel Prize for his work in radiation genetics. He established that gene mutations produced by ionizing radiation are not different in their effect from the mutations produced by other agents.

Thus, any nuclear war-produced genetic damage would not be manifested in unfamiliar ways, such as the birth of two-headed monsters. Rather, there would be a statistical increase in the number of the various types of genetic-related diseases and disabilities that occur in today's world.

Extensive laboratory and field studies are underway. The latter include studies of humans given radiation for therapeutic and diagnostic purposes, people involved in nuclear accidents, and the survivors of Hiroshima and Nagasaki.

During the 1967 symposium mentioned earlier, Dr. Dunham of the National Academy of Sciences summarized the postattack genetic problem as follows:

> "The genetic effects would be lost, as at Hiroshima and Nagasaki, in all the other 'background noise'."

Since only a fraction of a human generation has elapsed since the 1967 symposium, only a meager amount of additional data based on subsequent human experience has been obtained. However, radio-genetic research results, based on many, many generations of fruit flies and a substantial number of generations of mice, have been produced and soon will be in the public domain. In spite of the problems of translating the results of animal data to man, these results should throw additional light on the subject.

However, these new studies are unlikely to result in major re-evaluation of the importance of this problem. Even though the radiation-induced genetic consequences of a nuclear war will add some degree of suffering to the attack survivors and to their offspring, these consequences will not threaten the survival of the society nor seriously impede the progress of recovery.

CONCLUSION

Could the United States recover following a massive nuclear attack? There is no unequivocal proof one way or the other — and most probably never will be. Everyone hopes, and most people believe, the question will remain untested.

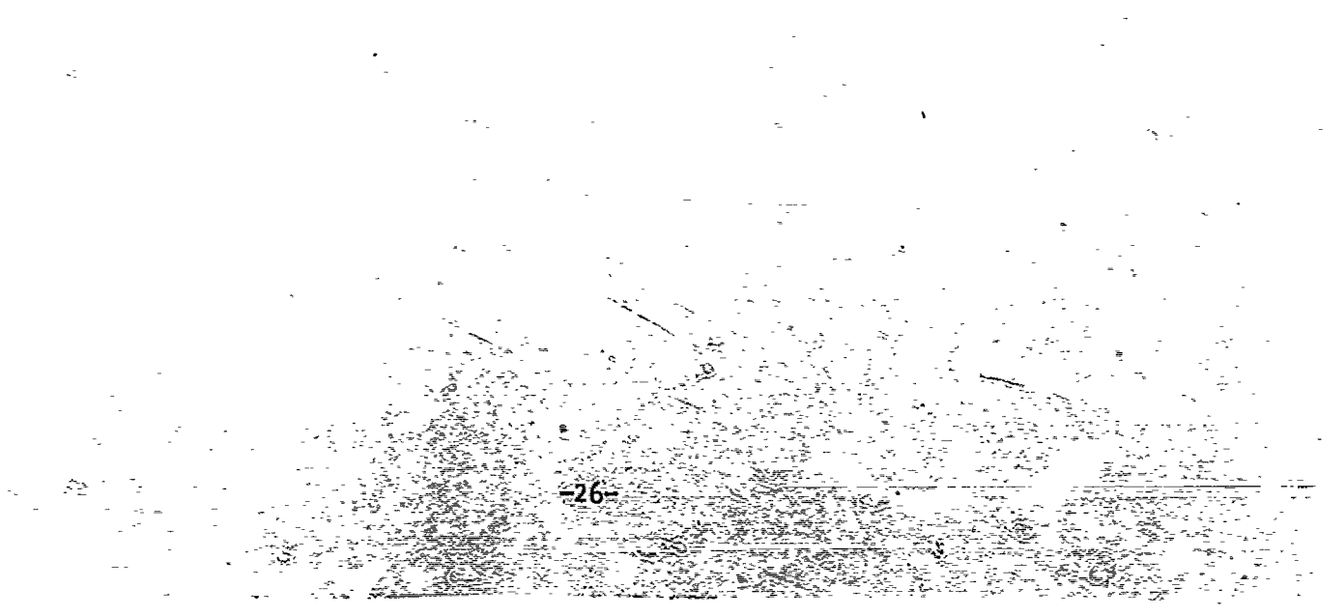
Why, then, have those who argue that recovery from a nuclear war would be impossible been so effective? In addition to the psychological factor discussed earlier, it may be because the question has been posed in a peculiar context. Those who support a stronger civil defense in this country have been challenged to prove beyond a reasonable doubt that the United States could recover from a nuclear attack. Otherwise, it is charged, any civil defense preparations would be a waste of time and money. What if those who oppose civil defense had to prove beyond a reasonable doubt that the United States could not recover from a nuclear attack as a basis for denying funds? Proof beyond a reasonable doubt for either proposition is an extremely difficult, if not impossible, task.

Has this country allowed itself to become so preoccupied with the basically unanswerable question about nuclear war recovery that it has overlooked answerable questions that are even more critical and pressing?

One such critical question is: Is the possibility of nuclear war zero, or even so low that it can safely be neglected? Almost everyone would agree that "zero" is not the proper answer. Whether or not it is negligible is a matter of judgment. However, the lessons of history, the many unresolved conflicts of interest that currently exist between the nuclear powers, and expenditures for nuclear armament suggest that "negligible" may be a dangerous underassessment.

Another critical question is: Could the chances for recovery from nuclear war be improved by civil defense preparations? There is a great deal of evidence as summarized in the body of this report that even modest civil defense expenditures could make an important contribution to the welfare and ultimate fate of the attack survivors, and thus to the prospects for recovery of the country.

The argument that a nuclear war could eliminate the human species or bring an end to civilization does not stand up when exposed to the light of objective examination. Without arms limitations, perhaps one side could eventually develop the capability to destroy the other side as a national entity. If this should happen, however, and war should occur, there would still be survivors, and these survivors — millions of human beings — would be better off if preparations have been made to insure recovery. In short, the case for recovery planning rests on prudence and humanitarianism. It is difficult to understand the years of neglect in the face of today's realities.



PART II: RESEARCH AND ACTION PROGRAMS TO ENHANCE RECOVERY PROSPECTS

HIGHLIGHTS

Life Support Requirements

There will be plenty of food, but thousands may starve unless measures are taken to see that it is available where needed:

- Locate surplus agricultural commodities near centers of population
- Make plans to salvage livestock
- Stockpile food near target areas
- Plan to increase household inventories during periods of tension
- Develop food distribution plans

Prevention of Epidemics and Disease

There is little need to fear widespread epidemics if relatively simple measures are taken:

- Plan to produce and distribute antibiotics, vaccines, and public health supplies following attack
- Plan to restore water and sewage treatment plants
- Plan to immunize the public

Economic Viability

Management is America's forte, but the complexities of the postwar world are so great that the only real fear of destruction of the national entity (other than military defeat) derives from doubt that we will be able to manage the physical resources available. We need to:

- Develop a realistic economic master plan
- Develop recovery strategies suitable for expected range of problems
- Plan now to function in a radioactive environment
- Identify essential functions of government and make plans to carry them out
- Make specific plans to deal with property rights, insurance, and debt
- Develop plans to restore functioning money, banking, and credit systems
- Plan resource-allocation technuiques
- Plan for restoration of the physical infrastructure
- Plan the restoration of the social and political infrastructure

Reduction of Late Radiation and Genetic Effects

The ravages of the "unseek killer," radiation, pose little threat to survival of the nation, but the human cost can be minimized by reducing exposures:

- Plan to provide and use fallout shelters
- Educate the public
- Procure instruments to measure radiation and train sufficient people in their use
- Enlist aid of the scientific community

Ecological Effects

Little can be done in advance to significantly reduce damage to the ecology which would result from nuclear war.

- Support and utilize on-going ecological reesearch by other government agencies.

PART II: RESEARCH AND ACTION PROGRAMS TO ENHANCE RECOVERY PROSPECTS

INTRODUCTION

> "... enhanced capability to protect the population in the event of a nuclear attack and to recover from such an attack ... need not await new research results"

This was a major conclusion of the National Academy of Sciences' Advisory Committee on Civil Defense in 1969. We knew then, and we know now, many of the things that could save millions of lives if a nuclear war should occur. Such actions need not await new research results. Among such actions:

1. Stockpile critical spare parts and fuel for transportation, utilities, and key infrastructure industries.
2. Stockpile and strategically locate food, medical, and public health supplies.
3. Develop detailed plans and equipment for converting industry to the production of items needed for survival.
4. Assure survival of key management, government, and technically trained personnel by special shelters and selective evacuation plans.
5. Disperse critical industries.

Balance is the key consideration, however. Most of the actions listed do not belong in a program costing barely $100 million per year, or one one-thousandth of the cost of our nuclear weapons-related offensive capabilities.

Within the context of today's civil defense budget, the most practical course — almost the only course — is to concentrate on planning, including plans for rapid implementation in time of perceived emergency.

Since the concentration in action programs must primarily be on planning, and since planning is closely related to research, this report is considering "action" and "research" measures together. It is believed that little research is needed to describe the recovery problem, a major objective of much prior research. We know what the problems are. Emphasis should shift to practical "problem-solution" research.

As a framework for discussion of action and research programs, the "obstacles-to-recovery" format will again be used. The list of obstacles is:

Life support inadequacies
Epidemics and diseases
Economic breakdown
Late radiation effects, and genetic effects
Ecological effects

LIFE SUPPORT INADEQUACIES

Past research has identified items critical to survival of the population following nuclear attack — food, water, shelter, to name the most important. In most cases, except for food, there would be no critical deficiency, although education in survival techniques and proper management are indicated. Pilot studies have been made to define the special needs of individual locations, but more of this research is needed. In addition, the following actions, all dealing with food, are listed in order of their importance:

1. Food will be critical, and its availability will depend on its location following attack. Consideration should be given to strategic location of surplus commodities.

2. Plans should be made to salvage vast numbers of livestock that would otherwise die of radiation exposure.

3. Stockpiles of food and other survival items should be located close to densely populated areas, especially in the Northeast.

4. Plans should be made to increase household reserves of food and other supplies during periods of heightened tension.

5. Fall-back plans should be developed for distributing food and other survival items in the event of attack (if actions 1 and 3 have not been taken.

EPIDEMICS AND DISEASES

Much research has been done in this area. However, different analysts who have estimated the potential magnitude of the postattack epidemic and disease problem reach different conclusions (For example, Katz in his report Economic and Social Consequences of Nuclear Attacks on the United States, Appendix III) sees this as a major concern whereas in PONAST II (See Key References) it is found to be much less significant in the context of the total survival problem.

There is no possibility of determining in advance the precise nature of the post-attack disease problems, since they depend upon the attack itself, the time of year, the state of public immunization, the speed with which public health measures can be taken, and many other factors. Actual results are likely to vary by individual locality. However, given assumptions about such factors, computer simulation models can be used to estimate the extent of the disease problem and the effectiveness of alternative medical-support systems. One such model was developed by the Research Triangle Institute (RTI) under the guidance of the Office of Civil Defense and the Public Health Service.

Since the time this RTI model was developed -- the late 1960's -- considerable progress has been made in the application of computer simulation techniques in the analysis of medical and public health problems.

A research effort to bring the RTI model up to date would be justified. With such a new model the magnitude of this obstacle-to-recovery could be estimated more accurately. The Public Health Service should again monitor and sponsor this effort.

Reseach is not needed to define or justify the kinds of action programs that are needed. They include:

1. Standby plans to assure production of broad-spectrum antibiotics, vaccines, antitoxins, and water and sewage treatment chemicals after a nuclear attack. Plans also must be made for the rapid distribution of these supplies under emergency conditions.

2. Plans to restore water treatment and other sanitation facilities and to improvise replacements.

ECONOMIC BREAKDOWN

In the preceding major section of this report dealing with prospects for recovery, we stated the "Unless more creative and imaginative study is applied to develop better strategies for managing the postattack economy than we now have, this barrier to recovery could turn out to be the most difficult of all." We have accordingly concentrated on the management problem in developing suggestions for action and research, and have chosen for convenience to include them under the economic "obstacle-to-recovery" although admittedly the discussion includes many factors such as social and political organization which are not ordinarily studied as economic matters.

Unfortunately, the complexity of this subject and its relative neglect provide few clear implications for dealing with the central problem of management. This massive problem, as well as most of the critical components thereof, could benefit from additional research before moving into what is ordinarily regarded as the action-plan status. But, just as clearly, much of the research which has been done has been performed without a clear understanding of the needs of management.

For these reasons, the process of planning, and the research required to facilitate and guide it, should proceed hand-in-hand.

The Need for a Master Plan

We need a new working plan for managing and guiding the recovery effort. The current plan, The National Plan for Emergency Preparedness, is inadequate, if not actually dysfunctional. This new plan must be one that focuses up to the realities of modern nuclear warfare and accepts the possibility that radical and unconventional types of measures may have to be undertaken by the society to overcome the damage and disruption of a nuclear attack. It must be a "living" plan that can readily be changed and improved as the need and the opportunity occurs. It must be a plan that recognizes the limits of central economic control and exploits the strength of our system of free enterprise. It must recognize and provide alternatives for quickly overcoming the many possible problems that could complicate restoration of a functioning economy - problems such as the need for currency reform, reestablishment of property rights, repair of the banking and judical systems and a host of others.

The general structure and concepts of such a working plan with its alternatives and options should be outlined at the earliest possible time.

Creation of such a plan would have many advantages besides development of an enhanced degree of readiness. It would help identify gaps and contradictions as a basis for further analysis. Development of the plan would stimulate the habit and discipline of "interactive thinking" and possibly the development of new disciplines to assist in this process. Finally, development of such a plan would provide a realistic statement of the problem in all of its aspects for both official and public use, superseding the somewhat exaggerated views in current circulation.

What are the major elements of such a plan? First would come a comprehensive statement of the problem. It would correlate all that we know (or think we know) about what life would be like in the postattack world. Much of the factual basis for this is available in reports and studies; much more may be in the minds of scientists, experts, and officials. The statement of the problem would not be attack-specific, nor would it be predictive. It would deal in probabilities. Where necessary, it would simply be descriptive rather than quantitative.

Specific Action Plans

Given this picture of the postwar situation, the need for many specific actions would become obvious. Some of these can easily be foretold: the need to limit radiation exposures, the need to meet minimum subsistence and health requirements, the need to avoid unessential production and consumption, the need to restore a functioning economic "base." Also obvious is the need to restore the transportation and communication networks, care for the sick and wounded, control the use of food and medicine, etc.

Plans for Essential Functions of Government

A third part of the plan would be a list of tasks to be undertaken by, and only by, government. There has been much debate over what the government should do and what it should not attempt to do, recognizing that its capabilities will in all probability be very limited.

The list of essential government functions would lead to the most important part of the plan; a shelf of action - alternatives to implement everything agreed upon as essential functions of government.

Plans by Essential Industries

In all probability, even in a postattack environment, government will rel, the private sector to produce and to distribute most of the essential goods and services. In addition to providing the conditions necessary to make such activity possible, government needs to work with industry (as it would have to during economic reconstruction) to develop action plans. This has been done to a limited extent in the communications field, and in approaching some supermarket chains to encourage them to plan the re-routing of food supplies in accord with postattack needs, but such planning by industry is uncommon.

This planning will not have to start from scratch - a considerable amount of research has been done. Most of the critical industries -- petroleum, petrochemical, steel, aluminum, food processing, control instruments, and others -- have been studied to evaluate their vulnerability to nuclear attack and to investigate the problems of bringing them back into production. Also available are the results of studies of potential bottlenecks and imbalances among the industrial sectors. There is plenty of material to work with.

Studies to support the management plan are as follows:

(1) Investigative techniques We have identified the need for a completely new and different detailed operational plan. The current one simply will not work. It was conceded that this new plan would have to be tentative and judgmental. Of all the gaps in knowledge that we have identified, the most serious is the lack of a truly comprehensive understanding of the totality of the problem.

Nor is this situation likely to change. There are so many variables and so little hard data that any conceptual model is likely to appear ridiculously oversimplified at the same time that it appears ridiculously complicated.

Without expecting too much from the project, (and certainly without waiting for it to be completed) is is suggested that a prime topic for innovative research is the subject of improved research techniques to fill this gap.

It is difficult to be precise in defining this requirement. The need is obvious. We have concluded that "management" is likely to be the single most important factor in determining the pace of recovery. Management is a kind of knowledge which presupposes understanding of how things fit together and interact -- the "big picture." Without such knowledge, bad management could waste resources and jeopardize recovery.

It should not be understood that we are suggesting a new and more complicated mathematical formulation of the problem. On the contrary, we have concluded that a practical working model of the postwar world will have to be largely judgmental in character since only the human brain is capable of the kind of selective and imaginative thinking required. Different "models" and different research techniques are needed for each of the major phases of the recovery process. There are at least three of these phases: survival, reorganization, and finally, recovery. Some investigators prefer to add a fourth, recuperation, preceding recovery.

In addition to mathematical modeling, war gaming, scenario development, systems dynamics, network analysis, and critical path analysis, other techniques can be helpful. But no technique appears fully adequate at present. In approximately 40 interviews with persons associated with civil defense research, we never failed to raise the question of investigative method and it was generally agreed that this is indeed a major need.

It is, therefore, suggested that a research prospectus be developed dealing exclusively with investigative techniques. It could be advertised for competitive proposals, similar to procedures used by the National Science Foundation. The more promising ideas could be selected for small developmental contracts. Any that show real promise could be further developed for use in operational planning.

The essential problem is to strike a proper balance between objective fact and intelligent working hypothesis. The statistician knows that nothing is ever 100 percent and success in life consists in knowing what is "good enough."

(2) Economic recovery strategies This is another project for the creative economist. Its objective is to provide alternative general strategies suitable for a range of plausible situations. It would be

problem-oriented. One problem might be to devise suitable "reorganization" strategies given a series of hypothetical attack situations provided by the government. For example, under what circumstances would the preferred strategy be to abandon the northern-tier states for a prescribed period because of heavy destruction and/or shortage of fuel? Another example: Under what circumstances would the indicated action be to decontaminate and rebuild stricken metropolitan areas, or parts thereof? How could such strategies be carried out smoothly and efficiently? What constraints and costs would have to be overcome?

A somewhat different problem would be to define the elements of a functioning minimum economy, assuming a limited number of hypothetical attack situations. The United States is a high-technology society, much of which would survive. Would a nuclear attack cause the country to regress to a primitive level -- the man with the hoe? Most economists deride this, but little thought has been given to prototype economic systems which might, in fact, be imposed by necessity following a nuclear attack, or for strategies which would gradually lead to wider areas of cooperation and increased specialization -- that is, to recovery.

One more example of problem-oriented economic research: Devise a list of actions which would almost certainly be right and useful and which ought to be taken immediately under almost any attack condition during the survival phase. One such action might be to encourage immediate resumption (actually continuation) of agricultural production in areas untouched or only lightly affected by radioactive fallout and to allocate the necessary resources for this purpose. Another would be to select certain industries or plants for priority treatment; petroleum refining, antibiotics, vaccines, for example. The project would include specific actions necessary to carry out these general strategies, together with pros, cons, and caveats.

(3) Impact of a radiological environment on economic recovery

This is the big new factor which must be taken into account in making economic decisions. Too often the economist has simply assumed-away this restraint in devising economic recovery plans. It is appropriate, therefore, to try to approach the entire economic recovery problem considering the constraints of radioactive environment, to identify the additional costs, restraints, behavioral problems, measurement, and communication problems,

operational and control problems, and long-term vs. the short-term trade-offs. Other aspects of the radiation problem are dealt with elsewhere, but it is especially appropriate that it be treated as part of the problem of potential economic breakdown.

(4) Essential functions of government in economic recovery There has been much controversy, but very limited real study of the problem of the essential role of government in managing economic recovery. Assuming, as one must, that the government can do very little, what must it do? What essential functions can be taken only by government? The National Plan for Emergency Preparedness states that "the Federal Government by virtue of its war powers must exercise pervasive direction and control in the interest of a national survival." There can be no question that the Federal Government, and only the Federal Government, must handle foreign relations, defense, major decisions regarding relocation of population, and so on. But there is serious doubt about the usefulness of nation-wide production plans developed by the Federal Government, or how they could be implemented in the early phases of the recovery effort. The objective of this research would be to examine this controversy much more closely, looking at the tasks to be done, the powers and capabilities of government, the data and analytical requirements, and so on. A general list of essential economic functions for government at all levels would be very useful, partly because it would help terminate what is believed to be a largely sterile debate over abstract economic ideology and concentrate effort instead on specific tasks.

(5) Property rights, indemnification, insurance, debt This clutch of problems should be considered as a unit. The objective of the research would be development of practical plans, including alternative plans, suitable for inclusion in more general plans for managing economic recovery.

Next to the act of physical survival itself, the handling of this may be the most important key to success or failure in restoring production and political stability. Questions of equity are seemingly pitted against considerations of efficiency. Questions of equity appear to demand immediate and widespread redistribution of surviving assets, while questions of efficiency would appear to argue against redistribution. Other considerations argue for immediate nationalization of productive assets, among them the need

of the government to insure political control and revenue. (As one of our conferees put it, "almost nobody is going to be filling out Form 1040 in the months following a nuclear attack.")

The problem of property rights has many aspects. It begins with certain necessary assumptions: that the destruction of property will be enormous and widespread, but capricious. Physical assets will be destroyed, damaged, denied (by fallout) or spared, depending upon their location. Some sections of the nation will be more heavily damaged than others. Owners of equities will suffer more than owners of real property for several reasons; equities represent a claim on a flow of earnings which will probably be stopped; they represent a claim expressed in dollar amounts which will probably decline in value to almost nothing very soon after attack; and finally, the evidences of ownership in equities will be destroyed in many cases. Owners of cash will find banks closed. Insurance companies will almost certainly be forced to default on their obligations despite nuclear-war escape clauses written into most policies. Even if they pay, they will pay in fixed dollar amounts, and, as noted, dollars will probably be worth very little. The management of debt poses related problems; there will almost certainly be debt moratoriums, followed later by readjustments. In general, debtors will be fortunate; they may not be able to find the owners of their mortgages!

Windfall benefits could also accrue to the owners of land or businesses in untouched areas, and to owners of stocks of food, medicines, etc.

One of the most difficult aspects of the property problem will be the establishment of valid titles, the settling questions of succession in the absence of wills, and reestablishing the right to buy, sell, or lease. Special procedures will clearly be needed to effectuate whatever policies are decided upon. Here again, the planned government action must be suited to the expected government capability.

(6) Money, banking, and credit The objective of this research would be to study the probable conditions affecting money, banking, and credit following a nuclear attack, and provide alternative plans for phased restoration of such financial systems.

Although the value of money is ultimately dependent upon the goods or services it will purchase, the monetary system itself is created by government, backed by government, and manipulated by government.

It is clear that a nuclear war would destroy assets, banks, and evidences of ownership. It would disrupt the flow of goods and services. Initially, nobody would know what preattack money would be worth. Exchange would be expected to be based on barter in local areas. Commandeering of survival supplies would also be expected -- better done by government with the issuance of emergency scrip than by desperate mobs acting out of necessity.

Resumption of large scale economic activity would depend upon restoration of an acceptable medium of exchange.

Given the widespread destruction of assets and the cessation of economic activity, upon what could a functioning monetary system be based? Gold is one obvious choice, but our supply of goal is limited, and gold certificates would not be amenable to the expedient depreciation of the currency, which may be a very desirable option to a hard-pressed government. Another possibility is basing the currency on the value of some known and tangible asset, such as food stockpiles. This, however, is probably more appropriate as a backing for work-scrip in the early postattack or survival period.

A problem to be considered is the relationship of the postwar monetary system to the prewar system it will replace, and the problem of war-damage compensation discussed in the preceding section on property rights.

(7) Resource allocation and the role of price; futures markets

The objective of this research: to develop methods for allocation of resources to achieve national economic goals and promote economic recovery.

In a free enterprise society, the price of competing goods in a free market economy is the primary determinant of what is produced, by whom, and for whom. It is an efficient method of resource allocation.

During World War II and the Korean conflict, the free play of economic forces was judged incompatible with the imperative need to convert America's mighty industrial plant in order to produce 60,000 airplanes, vast

numbers of tanks, military vehicles, munitions, and ships. To insure success of the greatest industrial war effort in history, it was necessary to curtail or eliminate competing consumer demands for automobiles and other consumer durables, and convert the entire system to war production.

The basic solution to harnessing the private enterprise system, (arrived at after much trial and error), was selective control and allocation of critical raw materials such as steel, aluminum, rubber, petroleum, and chemicals, plus manpower, transportation, and whatever else was in short supply. This system, known as the Controlled Materials Plan (or CMP), combined with well-publicized production goals, government cost-plus contracts, and the outright ban on competing goods, was the heart of the successful World War II system. The system was supported by credit controls, high taxes, and a great surge of patriotic support. The transition was eased by the presence of much unused capacity, including high unemployment, as the war began.

Conditions would be quite different following a nuclear war. The functioning economy will have become temporarily paralyzed. Physical destruction and appalling distress would characterize the social order. Starvation, disease, and civil disturbance could be expected in isolated communities. The problems of the government would be much different than they were in the early 1940's and 1950's when it was a matter of setting goals and waiting for industry to file CMP requests. Unfortunately, much of the thinking about resource allocation is based on our successful World War II experience. Standby plans and orders to reinstate the system are in the emergency books waiting for proclamation by the President.

Allocation of scarce productive resources is a necessary function in any economic system, but whether price mechanisms, or the CMP system, would be appropriate to the early recovery period is a matter of grave concern which has so far received little attention. It would be necessary to proscribe certain production while at the same time lending every assistance to restoring production deemed essential. If private enterprise lacks the necessary conditions or courage to undertake such production, government-guaranteed markets or even temporary nationalization may be necessary. It is hoped that such action would be temporary and that functioning free enterprise could resume its role of resource allocation at an early date.

The task of this proposed research remains clear, however; (a) to explore more fully alternative means of resource allocation suitable to a range of conditions following nuclear attack to achieve economic recovery, and (b) to prepare standby plans to effectuate them.

(8) Restoration of the infrastructure: physical plant The objectives of this research would be; (a) to define minimum requirements for economic recovery of such vital infrastructures as transportation, communications, power, water, and sewage; (b) to summarize the vulnerabilities of each infrastructure system to the effects of nuclear attack; (c) to identify critical components and supplies; and (d) to propose recovery strategies and measures appropriate to each infrastructure system, including costs.

Numerous studies of transportation, communications, and power systems have been completed using damage assessment, input-output, network analysis, and critical-component-analysis techniques. These studies have led to certain conclusions, none of which are too surprising:

- There is a large amount of redundancy in most of our important utility systems, and the ability to substitute, repair, and patch up working systems is impressive. This should prevent prolonged breakdowns in undamaged or lightly damaged areas. In heavily damaged areas there would be little demand for service.

- Although physical plants may survive, fuel and consumable spare parts would be in very short supply. This situation would be greatly ameliorated by stockpiling and hardening of certain critical elements.

Many of the infrastructure studies have ignored the operational problems arising from ambient radiation.

In general, this applies to other aspects of the infrastructure problem; vulnerabilities have been identified in general terms, but comprehensive plans for restoration are yet to be developed. When such plans are completed and costed, a valuable input to the development of general economic strategies will be available since it will be possible to estimate more accurately the relative cost of repair vs. abandonment of damaged areas.

(9) Infrastructure: social and political systems (except financial) The objective of this research would be (a) to determine the necessary political and social systems or services from the standpoint of economic recovery; (b) to assess their vulnerability; and (c) to propose ameliorative action plans.

This is a limited proposal -- limited to the social and political systems required for economic recovery. It is not a continuity-of-government or command-and-control study in the more comprehensive and customary context. Instead, it would keep the focus on the economy.

Economic activity takes place in an environment of law and social order. Courts resolve disputes and enforce contracts. Local government insures law and order and provides fire protection and other vital services such as collection of trash and garbage. Government would also have many extraordinary responsibilities following a nuclear attack: caring for refugees and orphans, rationing, monitoring and controlling radiation exposure, etc. It is important that the minimum essential conditions for economic recovery be identified and suitable plans developed.

This is an appropriate place to note again that the research program does not include studies of the general political system nor of behavioral psychology in general. The reason for this is that the practical value of such studies is debatable, research objectives difficult to define, and practical study techniques even more elusive. Rather, it is suggested that each of the recovery tasks be regarded as having a political and behavioral aspect, just as each will take place in a radiological environment. The need is to integrate these neglected factors with practical civil defense plans.

LATE RADIATION EFFECTS, INCLUDING GENETIC EFFECTS

The research and the action programs that relate to reduction of late radiation effects -- increased malignacies and other life shortening manifestations of radiation exposures, and the genetic effects -- manifestations of radiation injury that would occur in future generations, are almost identical. Namely, they involve the reducing of radiation exposures. (There are some differences: For example, radiation expsoures to those over child-bearing age do not produce genetic damage.) But for both of these potential obstacles-to-recovery the major opportunity for improvement lies in improved radiation protection at the time of attack — better fallout shelter, and better plans for using it. Radiation control equipment (dosimeters and survey meters) and operational exposure criteria and plans are essential, but they can in no way compensate for protection inadequacies that existed at the time of attack.

The "problem definition" part of the research is in very good shape as a result of extensive research sponsored by the Atomic Energy Commission and others. The expected long range consequences of radiation exposures are well understood.

The "problem solution" research has also received considerable attention. We know how to reduce radiation exposures, how to decontaminate, and how to make and use good instruments. What we need are action plans to provide better fallout protection and to use it. We need to enlist scientists and professional radiologists to help plan and to advise in the event of actual need. But perhaps most importantly there is a great need for public education. We stress here as we have elsewhere in the report that the basic principles of radioactivity, radiation effects, and means of protection are little understood. In fact, much of what "understanding" exists is highly distorted. A factual and comprehensive public education program is badly needed.

ECOLOGICAL EFFECTS

We do not believe that the agency responsible for nuclear preparedness planning (FEMA) need become directly involved in research or action-programs related to ecological damage from nuclear attack. Enough research and analysis has been done to provide confidence in the following two assumptions: (1) The long term ecological consequences of nuclear attack would not be so severe as to prohibit or seriously delay recovery, and (2) No practical amount of preattack planning or preparations is likely to significantly reduce the damage to the ecology that would occur, or speed up the rate of recovery from such damage.

There is one caveat: As discussed elsewhere, the potential of a major increase in ultraviolet radiation because of ozone depletion in the stratosphere as a result of nuclear detonation needs further evaluation. Should this turn out to be a serious potential threat, research is needed to determine the possible impact on the ecology. However, unless this research indicates the ultraviolet problem to be more serious than is indicated by the evidence available today, such research does not appear to be warranted.

Does this mean that the research on other possible effects of nuclear explosions such as great fires or wide scale contamination by various types of radioactivity is unnecessary? By no means. Not only is such research needed for basic scientific purposes, but for normal peacetime inputs to decisionmaking — about the locations and dangers of nuclear reactor power generators, for example.

PART III PERSPECTIVES: A FURTHER REPORT ON THE INTERVIEWS

The principal purpose of the interviews was to obtain criticism and suggestions about the summary of recovery prospects, (Part I of this report) and ideas about research and actions that could enhance these prospects (Part II). The results have been very helpful and are reflected throughout the previous parts of this report. However, during the discussions other issues almost invariably came up -- the kinds of issues that provide perspective on the postattack recovery problem as a whole.

The more salient of these issues are discussed below using the format of questions and answers:

QUESTION: Why is it that the Soviet Union takes civil defense seriously (including elaborate plans for civilian support of continued military operations and for postattack recovery) while the United States does not?

ANSWER: The answer that almost everyone agreed to is: The Soviet Union acts as though it believes nuclear war could occur, could be fought, and could be won, while the United States acts as though it does not believe any of these things.

If this is a true assessment, a very important question follows: Does the belief by the Soviet Union that nuclear war could occur stem basically from prudence (that is, they are more prudent than we are) or is it because they know something that we do not about their future intentions? Some of our conferees tend toward the prudence explanation -- some toward the idea that the Soviets plan a considerably more assertive role in world affairs, not ruling out the possibility of an eventual showdown with the United States.

QUESTION: Is there any way to settle once and for all the perennial question about the possibility of some catastrophic after-effect of nuclear explosions that could preclude the possibility of recovery?

ANSWER: The general consensus is "probably not." Most of the conferees agreed that any plausible hypothesis for catastrophe (increased ultraviolet radiation because of ozone depletion, for example) should be taken seriously and be thoroughly evaluated.

It was suggested that:

(a) A prestigious scientific nonpartisan organization needs to conduct (or directly supervise) the investigation not only to assure the quality of the work, but also to help assure that the public will have confidence in the results.

(b) This investigation should be sponsored, promoted and paid for by the people responsible for developing and planning the utilization of nuclear weapons, (in this case, the Defense Nuclear Agency) not the people responsible for protecting against them. The reasoning is that unless the decisionmakers involved in planning the utilization of nuclear weapons have full knowledge of all of the expected effects, they will lack a sound basis for making the plans.

(c) This investigation and the results should be completely open to everyone - especially to any potential adversary. Security considerations apply in reverse. If the United States knows something about the possible catastropic effects of nuclear weapons that the Soviets do not know, or vice versa, the one who does not disclose the knowledge may well become the victim.

QUESTION: Why not have a full exchange of the technical information relevant to civil defense, including recovery planning, between the United States and the Soviet Union (and all other interested nations)?

ANSWER: No disadvantages to a full-information-exchange policy were seen. A number of advantages were identified.

Examples include:

(a) A cooperative investigation with the Soviets of the "catastrophic class" of nuclear weapons effects could be less expensively performed and the findings probably could be more accurately pinned down. More importantly, this would lead to a shared assessment of the importance of these kinds of effects.

(b) By pooling our information about fallout, our procedures for risk analysis, fallout pattern prediction, and countermeasures probably could be improved. Since the resumption of atmospheric tests of nuclear weapons seems unlikely, the status of our knowledge about fallout phenomonology essentially will remain static. The Soviets have test data which, when added to our own, could help fill some important gaps for both sides.

(c) This kind of cooperation could promote the humanitarian purpose of civil defense.

QUESTION: How can good research people be attracted to work on civil defense (including recovery) problems?

ANSWER: The answer is simple. "Provide adequate support." The problems are interesting and challenging and if perceived to be important by national authorities and backed up by the allocation of funds, plenty of good people will respond.

QUESTION: Why can't the problems associated with economic recovery planning be solved through development of a more sophisticated computerized economic model to be available along with people trained in its use to guide the national postattack recovery effort?

ANSWER: There was no disagreement that economic and other models, computerized and otherwise, have their place in research studies and in training. However, there was strong skepticism among the economists with whom we conferred about the merits of computerized economic modeling as a basis for managing postattack recovery operations.

The skepticism arose from a number of considerations:

(a) There is insufficient knowledge about the intricacies of a modern economy such as that of the United States to predict how it will respond to current day-to-day perturbations let alone to the massive perturbation of a nuclear war.

(b) Economic modeling can be extremely costly. The appetite for data, programmers, computer time, and for analysts can be almost insatiable.

(c) An illusion of accuracy and of understanding can arise, diverting attention from more important fundamental issues. For example: computer models cannot handle the host of human behavior factors and other nontangible considerations such as solvency of business; disruption of normal business channels and the banking system; legal entanglements; loss sharing; inflationary pressures; a working money system, to name a few.

QUESTION: What about the problems of learning to function in radioactive environments where the radiation levels could be many times higher than they are today?

ANSWER: It was agreed that this is potentially one of the most serious postattack problems.

(a) There was a strong consensus that the most important need is for widespread public education about the basic characteristics of radioactive material, the radiation it emits and means to protect against it. (This education is badly needed today to contribute to the understanding of nuclear energy.)

(b) Several of the conferees pointed out the need to preserve, assess, organize and make available the tremendous amount of information about fallout that has been accumulated over the years (primarily in connection with atmospheric nuclear tests).

These may be the only real data we will ever have -- assuming the atmospheric test ban continues. Much of these data reside in the files and in some cases the personal notebooks of the people who were involved. Many of these people have already cleared out their files and gone into other work. Furthermore, the key to locating the data and its interpretation lies in the minds of the people who accumulated the data. Many of them are reaching an advanced age and will not be accessible much longer. A 2- to 3-year effort by a small group of researchers backed with the necessary authority could do much to save the only real data that we have -- the data that were accumulated at great costs of time, money and effort, and are available nowhere else in the world.

(c) The professionals, university personnel and professional practitioners must get involved in the planning and in creating a standby capability as analysts and advisors in the event the need should ever arise.

(d) Elsewhere we have discussed the urgent need for increased supplies of radiation measuring instruments. Without them recovery efforts in a radioactive environment would be severely handicapped.

QUESTION: What about the National Plan for Emergency Preparedness? (This is the official statement of national philosophies and responsibilities about postattack recovery. It is a plan promulgated by President Lyndon B. Johnson in 1964 and is supported by more than 40 separate annexes prepared by various federal agencies.)

ANSWER: The consensus is that the plan should be scrapped; scrapped now, not later when a replacement is ready. This act would serve as a commitment to provide something more responsive to the need. The present plan stands in the way of progress.

The Plan is deficient in concept. It is more appropriate for a mobilization war of the World War II type. It shown no real awareness of the extent of the damage to which society and the economy could be subjected in a present day nuclear war. Further it essentially ignores the problem of high ambient radiation levels. As it stands the Plan is a plan for something else - a relic of times when nuclear war was just beginning to be understood. (Paradoxically, these were the times when the possibility of war was taken more seriously - as the existence of the plan itself testifies.)

QUESTION: Why not assign responsibility for recovery research to the Federal agency which has the most closely-related peacetime responsibility:

ANSWER: This is a good idea, and the only one that makes sense in highly technical areas.

The Defense Nuclear Agency is the logical agency to conduct or sponsor studies relating to effects of nuclear weapons, both direct and indirect, and to general vulnerability, since it must do this anyway to discharge its responsibility to provide war planning information to the Defense Department. Similiarly, the Communicable Disease Control Center of the U.S. Public Health Service should be responsible for planning communicable disease control following nuclear attack. Also the Public health service is the logical agency to take on food and water contamination control research as its responsibility. The Department of Energy (successor to the Atomic Energy Commission) is best qualified to provide technical support and research in the field of biological effects of ionizing radiation both acute and long term.

The responsibility of the Federal agencies for civil emergency planning is clearly spelled out in Executive Order 11490 as amended, but, unfortunately, this "delegation" of responsibility has been thwarted by failure of Congress to honor funding requests, and, in some cases, by resistance from executive branch agencies.

As part of the new look in Federal emergency management, consideration should be given to specific requests by FEMA to specific agencies to undertake specific research or emergency preparedness tasks.

APPENDIX I: THE CONFEREES

An alphabetical list of persons interviewed, their affiliations, and their fields of expertise of particular interest to this project. We have not attempted to identify all of the staff members who may have been present during parts of the conferences.

Stanley Auerbach -- Oak Ridge National Laboratory
Leading authority on expected ecological effects of nuclear attack.

John Auxier -- Oak Ridge National Laboratory
Expert in dose evaluation and the biological effects of radiation exposures.

Robert U. Ayres -- University of Pittsburgh
Analyst of "catastrophic class" of recovery problems and critic of research methodology.

John Billheimer -- Systan Corporation
Food availability and distribution analyst.

Gerhard D. Bleichen -- Past President, John Hancock Life Insurance Co.
Expert on fiscal and economic problems.

Harold Brode -- R & D Associates
Expert on nuclear weapons effects.

Steven Brown -- Stanford Research Institute
Expert on agricultural vulnerability to nuclear attack.

William Brown -- Hudson Institute
Expert in wide range of social, psychological and economic effects of nuclear war.

William Chennault -- Human Science Research, Inc.
Expert in human behavior aspects of nuclear protection planning.

Conrad Chester -- Oak Ridge National Laboratory
Headed the civil defense research effort at ORNL.

William Chipman -- Defense Civil Preparedness Agency (FEMA)
Long-term student of U.S. civil defense.

Richard Cole -- Environmental Science Associates
Expert on biological effects of internal emitters (I-131).

L. Joe Deal -- Department of Energy
Expert on long range radiation hazards.

George D. Divine -- Defense Civil Preparedness Agency (FEMA)
Contract monitor for certain on-going postattack research projects.

Francis W. Dresch -- Stanford Research Institute
Expert on postattack economic and organizational problems.

Richard Foster -- SRI International
Expert in U.S.-Soviet strategic analyses.

Jerome Frank -- Johns Hopkins University Medical School
Analyst and author in psychoanalytical aspects of international conflict.

Charles Fritz -- National Academy of Sciences
Expert on human behavior aspects of major disasters.

Leon Goure -- Advanced International Studies Institute
Leading authority on Soviet civil defense and recovery.

Norman Hannoonian -- Rand Corporation
Expert on postattack economic viability.

Jack Hirshleifer -- University of California at Los Angeles
Expert in post-nuclear attack economic recovery.

Francis P. Hoeber -- National Security Consultant
Expert in U.S.-Soviet strategic analyses.

Samuel P. Huntington -- Harvard University
Historian, expert in national security affairs.

Donald Johnson -- Research Triangle Institute
Expert in postattack health and medical problems.

Arthur Katz -- Department of Energy
Author of report issued by Joint Committee on Defense Production on Economic and Social Consequences of Nuclear Attacks on the United States.

Richard K. Laurino -- Center for Planning and Research, Inc.
Expert in a wide variety of postattack viability considerations.

Clarence R. Mehl -- Sandia Laboratories
Expert in nuclear weapons effects.

Melvin L. Merritt -- Sandia Laboratories
Expert on radioactive fallout.

John Nocita -- Federal Preparedness Agency (FEMA)
Expert in civil emergency preparedness planning.

Peter G. Nordlie -- Human Science Research, Inc.
Expert on human behavior aspects of major disasters and nuclear protection planning.

Richard Park -- National Council on Radiation Protection and Measurements
Broad range of scientific and technical aspects of civil defense.

James C. Pettee -- FPA Consultant
Expert in postattack industrial production projections.

Charles T. Rainey -- Center for Planning and Research, Inc.
Expert in radiological monitoring and reporting.

Robert Rapp -- Rand Corporation
Expert in radioactive fallout prediction.

Leo Schmidt -- Institute for Defense Analyses
Expert on nuclear war-related risk analysis

Peter Sharfman -- Office of Technology Assessment
Principal author of the Office of Technology Assessments' report, The Effects of Nuclear War.

Bernard Sobin -- Civil Aeronautics Board
Expert in postattack economic recovery.

Ralph E. Spear -- Former OEP official
Role of civil defense in the national strategic context.

Lewis V. Spencer -- National Bureau of Standards
Broad range of scientific and technical aspects of civil defense with emphasis on postattack radiation control procedures.

Walmer E. Strope -- Center for Planning and Research, Inc.
Expert in overall civil defense research programs, currently analyzing cost-effectiveness of various civil defense measures.

Lauriston S. Taylor -- Past President, National Council or Radiation Protection and Measurements
Postattack radiation exposure control problems and procedures.

R. William Thomas -- Institute for Defense Analyses
Expert, postattack economic analyses.

Luke J. Vortman -- Sandia Corporation
Expert in nuclear weapons effects.

Hugh Wilson -- Oak Ridge National Laboratory
Expert in radiological instrument design.

Sidney G. Winter, Jr. -- Yale University
Expert in post-nuclear attack economic recovery.

Paul E. Zigman -- Environmental Science Associates, Inc.
Expert in radiological fallout phenomena and associated research.

APPENDIX II: KEY REFERENCES

The listing of references is designed more as a guide for further reading than as an exhaustive inventory of the research that has been done on the subject. Also, we have limited the selection to focus most directly on the subject "Recovery of the United States from Nuclear Attack."

For those readers who want to conduct an extensive study of the research that has been done, we highly recommend they visit the FEMA Research Library. A computer printout of the contents of the Library conveniently arranged by subject matter is available as a basis for locating reports of interest.

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APPENDIX III

CRITIQUES OF RECENT REPORTS

1. Office of Technology Assessment, The Effects of Nuclear War, Washington, D.C., 1979.

Auspices: The study was performed at the request of the Senate Committee on Foreign Relations by the Office of Technology Assessment, using staff, personnel on detail, and consultants.

Authors: Peter Sharfman, Project Director

OTA Project Staff: Lionel S. Johns, Jonathan Medalia, Robert W. Vining, Kevin Lewis, Gloria Proctor, Henry Kelly, and Marvin Ott

Consultants: Advanced Research and Applications Corporation, Analytical Assessments Corporation, General Research Corporation, Santa Fe Corporation, Systems Science and Software. Stuart Goldman, Nan Randall, George R. Rodericks, and Ronald Stivers

Advisory Panel: David S. Saxon, President, University of California and sixteen other distinguished persons.

Scope and Objectives: To describe the full range of effects of nuclear war on the civilian population, economies, and societies of the United States and the U.S.S.R.

P.3 "... But the fact remains that nuclear war is possible, and the possibility of nuclear war has formed part of the foundation of international politics, and of United States policy ever since nuclear weapons were used in 1945.

The premise of this study is that those who deal with the large issues of world politics should understand what is known, and perhaps more importantly what is not known, about the likely consequences if efforts to deter and avoid nuclear war should fail."

Methodology: The study looked at four hypothetical attack cases, in each of which the Soviet Union was assumed to strike first and the United States to retaliate in kind:

Case 1. Attack on a single city - Detroit and Leningrad - with one 1-Megaton weapon or ten 40-kiloton weapons. (The purpose of this case was to provide "a kind of tutorial on weapons effects.")

Case 2. Attack on petroleum refining capacity limited to ten missiles.

Case 3. Counterforce attack limited to weapons in silos.

Case 4. Large scale attack on military and economic targets.

For each of these attacks, calculations of casualties (and in most cases physical destruction) were made using conventional damage assessment hniques.

The study includes a short chapter on civil defense in the United States and the Soviet Union, notes the major differences, and the major issues regarding the utility of civil defense measures.

Another chapter covers long-range environmental effects; ionizing radiation, ozone depletion, and damage to the ecology.

Among the appendices is a fictional account of life in the aftermath of a nuclear attack by Nan Randall, using a "host area," Charlottesville, Virginia, as the locale, and covering roughly the first following an attack.

Findings: Designed to meet the request of the Senate Committee on Foreign Relations for a study of the effects of nuclear war "which would put what have beeen abstract measures of strategic power into more comprehensible terms," (See letter of John Sparkman dated September 8, 1978, contained in Appendix A) the study is more concerned with seeing that most of the relevant questions are raised, and in making its findings readily understandable, than in making judgments or drawing conclusions in areas under dispute.

The study concludes that:

P.3 "... The effects of a nuclear war that cannot be calculated are at least as important as those for which calculations are attempted."

The study notes that large elements of uncertainty relate to weapons effects, weather, composition of the hypothetical attacks, and assessment techniques. The conclusion of the report is that actual damage is likely to be greater than that included in the calculations. In addition, secondary and indirect effects of destruction to social and economic organizations will be enormous, but essentially incalculable.

Looking particularly at recovery from nuclear attack, the study concludes that there would be "some years" during which the surviving economy would continue to decline. (p. 4)

The report notes differences between the United States and the Soviet Union as targets. The Soviet Union is favored by geography and by a political/economic system geared to emergencies; whereas the United States favored by a greater industrial capacity, and by more redundancy in its economic linkages.

Evaluation and Impact: The impact of this study is greatly enhanced by its OTA auspices, use of a prestigous advisory committee, and employment of Executive branch expertise. It is the first comprehensive report on the subject in several years, and comes at a timely juncture: a Congressional review of national security posture incident to its consideration of SALT II. The report is well-written and presented, and has had wide distribution.

These positive factors are somewhat mitigated by the indeterminate nature of most of the findings. It is useful mainly for bringing an unpopular but important subject to the attention of the policy-making establishment. It also focuses attention on many of the neglected secondary or synergistic effects of nuclear attack.

2. Katz, Arthur; Economic and Social Consequences of Nuclear Attacks on the United States, Washington, D.C., March, 1979.

Auspices: The publication of the report was commissioned by the Joint Committee on Defense Production. The views and findings, however, are those of the author.

Scope and Objectives: To examine the long-term social and economic effects of nuclear attacks on the United States. More specifically:

> P.2 "... the aim of the study is, first, to review the acceptability from a national standpoint of various levels of nuclear attack damage, and secondly, to examine a number of post-attack problems often neglected in the literature on the effects of nuclear war."

Author: Arthur Katz holds a PhD. from the University of Rochester. He has taught or held research posts at Wellesley College, Harvard University, and M.I.T. The research for this study was done partially while at M.I.T. Dr. Katz is now with the Department of Energy.

Methodology: The author examines the effects of four hypothetical attacks designed to inflict maximum damage on United States industry and population. His starting point is a study entitled Potential Vulnerabilities Affecting National Survival prepared by SRI in 1970 for the Office of Civil Defense.[1] Dr. Katz accepted the data base and targeting philosophy of the SRI study, in which an attack was designed against thirty-four major categories of industry. He modified the SRI methodology as follows:

[1] Goen, R. L., Bothun, R. B., and Walker, F. E., Potential Vulnerabilities Affecting National Survival, Stanford Research Institute, Contract DAHC 20-69-C-0186, September, 1970. (Although Dr. Katz modified the attack damage criteria used in this SRI report, he did not discuss his reasons for the changes with the SRI personnel or ask them for comments about their validity.)

P. 41 "The physical damage criteria employed in the present study differ from those used by the PVANS analysts. Specifically, the 5 psi instead of the 9 psi blast effects contour is the criterion for severe damage to industrial capacity. Additionally, casualties were assumed to be 50% dead and 30% injured within the 5 psi contour; 10% dead and 40% injured between the 3 and 5 psi contours; and 2% dead and 30% injured between the 1 and 3 psi contours.

"These new criteria were considered more realistic than the PVANS criteria for two reasons: (1) the PVANS criteria did not account for destruction and disruptive effects beyond the 9 psi blast effects contour, and (2) they underestimated the effects that the collateral impacts (e.g., transportation losses, disruption of basic services such as electricity, fallout, etc.) as well as direct damage, would have on the effective utilization of a manufacturing facility."

The Katz study considers four attack cases from the standpoint of casualties and industrial damage; then, more generally, the interactive effects which might be assumed on food, energy, medical services, and education; and finally, the social and economic implications of the attacks.

Findings: Since the purpose of the study is to explore the "acceptability" of damage resulting from nuclear attacks, the author discusses the meaning of survival at numerous levels, ranging from biological survival, to survival of a "functioning national entity" with ability to "recover in a reasonable time" and play an "effective independent global role." Obviously, there can be no single definition of survival acceptable to all nations under all circumstances.

Mr. Katz then turns to the consequences of nuclear war that would have to be reckoned with by United States leaders, assuming the enemy was planning an attack designed to maximize casualties and industrial damage. He concludes that only 400 to 800 weapons would produce significant damage to people and industry, as follows (p. 9):

Attacks	% Casualties Total U.S.	% U.S. Industry Destroyed	Total Weapons Require
A-1	35-45	60-65	700-800
A-2	30-40	45-60	500-600
A-3	25-35	35-45	400-500
A-4	20-30	24-35	300-400

In addition, damage to food production, medicine, and education, (to consider just three important industries) would be even greater due to destruction of the social and economic infrastructure. The social, psychological, and political implications could be even more serious, although there is no way in which these effects can be quantified.

Evaluation and Impact: This study makes its major contribution by its insistence on the importance of the interactive effects of nuclear destruction which go beyond the primary measures of numbers of casualties and damage to industry.

The impact of the study is somewhat weakened by the assumption that a potential enemy would target industry and population and ignore military targets.

The purpose of the study is to examine the question of "acceptability" of damage from nuclear attack. The author does not reach any conclusions on this. Plainly, the concept of "acceptability" as seen by the national command structure of either the United States or the U.S.S.R. includes more than a knowledge of weapons' effects. Almost no level of nuclear attack would be "acceptable" to a rational leader in a position to choose war/no war.

This study becomes essentially a treatise on the irrationality of nuclear war, and the author concludes, as most people do, that it is, in fact, irrational. Unfortunately, this does not exorcise the danger. If history proves anything, it is that most wars are acts of irrationality.

It is unfortunate that the study stops with its conclusion that war should be completely "unacceptable" and pays no attention to measures which could ameliorate some of the effects of nuclear war and speed recovery. Dr. Katz concludes with a recital of the arguments against evacuation of cities (that it would be difficult, confusing, and possibly even provocative), but neglects its significant potential for reducing casualties if war should come.

3. Berger, Howard M., A Critical Review of Studies of Survival and Recovery After a Large-Scale Nuclear Attack, R & D Associates, RDA-TR-107006-009. December 1978.

Auspices: Defense Nuclear Agency.

Scope and Objectives: The report is a critical review of ninety-four studies of both United States and Soviet Union survival and recovery after a large-scale nuclear exchange. Some of the studies involve attacks on the United States or the Soviet Union only; others involve attacks on both. The author's assessment of the individual reports is preceded by a forty-page overview which summarizes his findings and recommendations. The focus of the report is as much on methodology as on conclusions.

Methodology: Mr. Berger has a brief one to two-page summary and evaluation of the reports he finds relevant to the survival and recovery problem, whether or not they were originally intended for this purpose. His synthesis and general conclusions are presented in the overview.

Findings: Berger notes, but does not necessarily endores, the "overwhelming conclusion of the past studies ... that the surviving resources after a large-scale nuclear attack by the Soviet Union will be adequate for viability ..." (p. 3)

He notes, however, that such studies were in most cases not optimized to destroy viability, and that Soviet capabilities have increased significantly since most of these studies were made. He also notes that major reservations relate to the management of the postattack economy. He, therefore, focuses on the "management of the reorganization effort, information requirements of the reorganization effort, and related societal impacts." (p. 4)

> P.4-5 "Viability of the post-attack economy appears to be the most crucial issue affecting recovery. This is not satisfactorily addressed in the studies reviewed. The overriding unresolved issue which will affect viability, and therefore, the capability of the nation to recover is the ability of the nation to reorganize after an attack. In particular, the information requirements and communication requirements of the post-attack reorganization appear to be crucial."

Transportation and substitutability are likely to be critical issues, and both of them demand detail which is beyond the practical limits of input-output economic models.

Another critical issue, according to Berger, is the current lack of focus on potential instabilities and mismanagement of the economy.

Speaking of the importance of past studies as a basis for decisionmaking, the report notes:

> P.8 "Finally, if the results of an analysis of survival and recovery are to have a significant impact upon the decisionmakers throughout tne government, it is essential that they be believed by the decisionmakers. The studies reviewed here contain a bewildering array of conflicting results arrived at by using different assumptions, different data, and different methodologies. It is impossible to tell whether the differences in results are due to differences in assumptions, data, or methodology. Considering the extensive research currently underway, it appears well worth expending the necessary time, effort, and resources to gain a consensus of (official) opinion regarding appropriate assumptions, data bases, approaches, and promising methodologies."

Turning to specific recommendations, the author argues that separate models be developed for analysis of the various phases of recovery: survival, reorganization, recuperation, and finally recovery. Each of these models would have the level of detail appropriate to the problem. Each would be comprehensive enough to include financial, fiscal, monetary, societal, and other aspects of recovery, even though some of them cannot be quantified. The hierarchy of models recommended would be decision-oriented, as contrasted

with the vast majority of past studies which are merely descriptive. The report describes the characteristics of each of the survival and recovery phases, and how appropriate models might be constructed for each.

Evaluation and Impact: This is a technical report with limited distribution, dealing mainly with methodology. Nevertheless, it will be read with enormous interest by the research community, if not by decisionmakers, and clearly points the way in which considerable progress in postattack research can be made. The report is particularly noteworthy for its clear elucidation of the uses and limitations of economic models, and for its insistence on developing analytic techniques which are comprehensive in nature.

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SRI International
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Sunnyvale, CA 94086

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Radiation Theory Section
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Dr. John Billheimer
Systan Corporation
343 Second Street
P.O. Box U
Los Altos, CA 94022

Dr. Harold Brode
Pacific-Sierra Research Corp.
1456 Cloverfield Blvd.
Santa Monica, CA 90404

Oak Ridge National Laboratory
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Oak Ridge, TN 37831

Mr. Bert Greenglass
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Dr. Leon Goure
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Dr. Steven Brown
SRI International
Menlo Park, CA 94025

Disaster Research Center
Ohio State University
404B West 17th Avenue
Columbus, OH 43210

American Technical Assistance Co.
ATTN: Mr. Elwyn Bull
7655 Old Springhouse Road
McLean, VA 22102

Mr. Walmer E. Strope
Center for Planning and Research, Inc.
5600 Columbia Pike
Baileys Crossroads, VA 22041

National Council or Radiation Protection
and Measurements
ATTN: Dr. Lauriston Taylor
7910 Woodmont Avenue, Suite 1016
Washington, D.C/ 20014

Dr. R. William Thomas
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, VA 22202

Human Sciences Research
ATTN: Dr. Peter G. Nordlie
Westgate Industrial Park
P.O. Box 370
McLean, VA 22101

Dr. Stanley I. Auerbach
Director, Environmental Sciences Div.
Building 2110
Oak Ridge National Laboratory
Oak Ridge, TN 37831

Dr. Roger J. Sullivan
Systems Planning Corp.
1500 Wilson Blvd., Suite 1500
Arlington, VA 22209

University of California
Department of Economics
ATTN: Professor Jack Hirschleifer
Los Angeles, CA 90024

Center for Planning & Research, Inc.
Stanford professional Center
ATTN: Mr. Richard K. Laurino
750 Welch Road
Palo Alto, CA 94304

Mr. James A. Davis
Emergency Preparedness Division
Agricultural Stabilization and
Conservation Service
U.S. Department of Agriculture
South Building, Room 6628
Washington, D.C. 20250

Mr. William T. Cox
Agricultural Engineers
Federal Extension Service
U.S. Department of Agriculture
Washington, D.C. 20250

University of Pittsburgh
Department of Sociology
ATTN: Dr. Jiri Nehnevajsa
Pittsburgh, PA 15213

Dr. Sidney Winter, Jr.
Box 1A
School of Organization and Management
Yale University
New Haven, CT 06520

Dr. Richard Cole
Environmental Science Associates
1291 East Hillsdale Blvd.
Foster City, CA 94404

Mr. Charles Eisenhauer
National Bureau of Standards
Center for Radiation Research
Washington, D.C. 20234

Dr. Rudolph J. Engelmann
Division of Biomedical and
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Washington, D.C. 20545

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LTC Donald C. Anselm, USA
Joint Chiefs of Staff (SAGA/COPRA)
Room 1D942, The Pentagon
Washington, D.C. 20301

Dr. Howard Berger
Analytical Assessments Corporation
P.O. Box 9758
Marina del Rey, CA 90291

Dr. Ellery B. Block
Science Applications, Inc.
2109 West Clinton Avenue, Suite 800
Huntsville, AL 25805

Mr. Robert Hubenette
Center for Planning and Research, Inc.
2483 East Bayshore Road, Suite 104
Palo Alto, CA 94304

Joseph Russell, USN (Ret.)
Boeing Aerospace Co.
MS85/20 - P.O. Box 3999
Seattle, WA 98124

Mr. Gerhard D. Bleichen
200 Berkley Street
Room 800
Boston, MA 02116

Mr. William Chipman
Federal Emergency Management Agency
Washington, D.C. 20472

Dr. George D. Divine
Federal Emergency Management Agency
Washington, D.C. 20472

President
Naval War College
ATTN: Code 1212
Newport, RI 02840

LTC David A. Thomas, USAF
Defense Nuclear Agency
VLWS
Washington, D.C. 20305

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Scientific Service, Inc.
1536 Maple Street
Redwood City, CA 94063

Mr. Rogers Cannell
Woodward-Clyde Consultants
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Suite 401
Washington, D.C. 20006

Mr. John M. Miller MS8A-04
Boeing Aerospace Co.
P.O. Box 3999
Seattle, WA 98124

Mr. Edward Schuert
Woodward-Clyde Consultants
Three Embarcadero Center
Suite 700
San Francisco, CA 94111

Dr. James C. Pettee
2353 N. Oakland
Arlington, VA 22207

Dr. Charles T. Rainey
Center for Planning and Research, Inc.
5600 Columbia Pike
Baileys Crossroads, VA 22041

Dr. Robert Rapp
Rand Corporation
1700 Main Street
Santa Monica, CA 90406

Dr. Norman Hanoonian
Rand Corporation
1700 Main Street
Santa Monica, CA 90406

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National Council on Radiation
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Dr. Bernard Sobin
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Alexandria, VA

Dr. Luke J. Vortman, IIII
Sandia Laboratories
Albuquerque, NM 87115

Mr. Hugh Wilson
Oak Ridge National Laboratory
Oak Ridge, TN 37831

Mr. Paul E. Zigman
Environmental Science Associates
1291 East Hillsdale Blvd.
Foster City, CA 94404

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ABSTRACT

The probability of Nuclear attack on the U.S. is probably low, but not negligible. This report, based on review of literature and interviews with more than 40 recognized experts, concludes that there is no known obstacle-to-recovery if attack should occur. Considers Life-Support Inadequacies, Epidemics and Diseases, Economic Breakdown, Late Radiation Effects (and Genetic Damage), and Ecological Effects. Concludes that realistic management plans and plans to function in a radioactive environment are most critical needs.

Suggests research and action programs.

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